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A DECISION METHODOLOGY FOR THE ALLOCATION OF MACRO LEVEL TRAINING RESOURCES

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This paper describes a process for utilizing existing data bases and, if necessary, developing new ones to answer key policy questions regarding DoD expenditures of funds for various forms of training. It presents a general cost-effectiveness methodology for performing analyses in support of questions focused on the desirability of increasing, decreasing, or holding constant DoD funding for various training modalities. This methodology draws on proven principles of training cost analysis, makes optimal use of existing training cost and effectiveness data and takes a requirements-oriented, functional point of view. The innovative aspect of our approach is the development of a systematic Training Funds Decision Methodology (TFDM), which is demonstrated by a case study example. If TFDM ultimately proves valid, acceptable, and supportable by existing/planned data repositories, it could be translated into specifications for an expert decision support system.

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GLOSSARY

ADPA	American Defense Preparedness Association
ASD(FM&P)TP	Assistant Secretary of Defense (Force Management and Personnel) Training Policy
CAI	computer assisted instruction
CBI	computer based instruction
CBV	Compensating Budget Variation
CER	Cost Effectiveness Ratio
CES	cost element structure
CMI	computer managed instruction
CTMM	Canadian Training Management Model
DASD	Deputy Assistant Secretary of Defense
DSB	Defense Science Board
DTP	Directorate of Training Policy
EBV	Equivalent Budget Variation
FYDP	Fiscal Year Development Plan
GAO/DoDIG	General Accounting Office/DoD Inspector General
ISTN	initial skill training number
IVD	interactive videodisc
LCC	life-cycle cost
MATRIS	Manpower and Training Research Information System
MM&PP	Military Manpower and Personnel Policy

MMTR	Military Manpower Training Report
MOS	Military Occupational Specialty
NSIA	National Security Industrial Association
O&M	operations and maintenance
OASD(FM&P)	Office of the Assistant Secretary of Defense (Force Management and Personnel)
OTJ	on-the-job
R&D	research and development
TCi	training cost per individual for one training option
TCR	Training Cost Ratio
TEi	training effectiveness per individual for one training option
TER	Transfer Effectiveness Ratio
TFDM	Training Funds Decision Methodology
TMM	Training Management Model
TP	Training Policy
TPDC	Training and Performance Data Center
TTCP	The Technical Cooperation Program
TTDB	training technology data base
UNITREP	Unit Status and Identity Report

I. EXECUTIVE SUMMARY

The purpose of this paper is to describe a process for utilizing existing data bases and, if necessary, developing new ones to answer key policy questions regarding DoD funding for various forms of training. This paper presents a general cost-effectiveness methodology for analyses that support questions on the desirability of increasing, decreasing, or holding constant DoD funding for various training modalities. Although our methodology will be demonstrated in the context of a specific case study, it is designed to be applicable to a wide range of training resource allocation problems.

This methodology draws on proven principles of training cost analysis put forth in detail by other authors, as well as DoD cost-effectiveness analysis methodologies developed and applied by practitioners. It is designed to make optimal use of existing data on training cost and effectiveness. The methodology emphasizes simplicity and robustness over detail and complexity and, with detailed refinements and augmentations, applies to the entire spectrum of potential questions on training cost-effectiveness.

This summary describes our conceptual approach to the identification and assessment of cost and effectiveness data required for the support of training-policy decisions. Our approach is based on a requirements-oriented, functional point of view (i.e., we define the problem and determine what we need to fix it). The innovative aspect of our approach is the development of a systematic Training Funds Decision Methodology (TFDM), which is demonstrated by a case study example. The TFDM is suggested for use by training policy-makers in the development and justification of their funding requests to Congress and subsequent resource allocation decisions. Should this funding methodology ultimately prove to be valid, acceptable, and supportable by existing or planned data repositories, it could be translated into specifications for a decision-support system.

The remainder of this summary describes briefly the need for a TFDM, the overall purpose of such a methodology, the specific objectives that must be achieved to establish a valid TFDM, a description of the process employed in its development, and conclusions and recommendations.

A. PROJECT GOALS AND OBJECTIVES

1. Goals

The project goal is to "assist the Training Policy Directorate, OASD(FM&P) in assessing the adequacy of training cost data bases in support of OSD and the Services and their utility in supporting training policy decisions" (IDA Task Order No. T-L2-407 of 23 May 86). To accomplish this goal, the IDA team examined the macro-level training funds data base at the Training and Performance Data Center (TPDC) to determine its completeness, relevance, and utility in the development of training policy by using hypothetical funding decisions. Based on these findings, the task was modified to include case studies of selected funding decisions as a means of testing the cost and benefit analysis capabilities inherent in the TPDC data base. Additionally, we identified the cost and effectiveness data and data bases necessary to assist OSD and the Services in formulation and support of training policy decisions at the DoD level.

Since the focus of this study was the development of data requirements for training decisions rather than the evaluation of an existing data capability, we developed a functional architecture for a decision methodology. This methodology will support "top-down" training policy development by employing requirements derived from the tasks to be trained as criteria for identifying and evaluating data elements from existing resources.

2. Technical Objectives

The objectives of the task are threefold:

- Analyze the training policy-making (decision) function
- Develop a methodology for cost-effectiveness analysis in support of the training policy-making function
- Demonstrate the methodology via a case study.

a. Objective 1: Analyze the Training Policy-Making Function

An analysis of the training policy-making function was conducted on the basis of personnel interviews with training managers and the mission statements for the Directorate of Training Policy (DTP) within OASD(FM&P). We began with a concise statement of the mission and functional responsibilities of the DTP. Next, the role of a DoD training policy-maker (macro-level training manager) was defined and used to deduce the content and level of aggregation requirements for training data and the decision-making tools to support him.

From this analysis we developed an understanding of the process to be supported by the TFDM. First, we reviewed and analyzed the Training Management Model (TMM) for the conversion of resources to training products and training management. Second, we examined relevant aspects of the Canadian Training Management Model (CTMM). These included information requirements, decision contexts, and efficiency in cost-effectiveness analysis. Next, we investigated the application of a previously proposed cost element structure (CES) for training programs, courses, and devices. Finally, performance requirements for the training policy-making function were analyzed to guide the development of a comprehensive TFDM.

b. Objective 2: Develop a Methodology for Cost-Effectiveness Analysis to Support the Training Policy-Maker

In support of this objective, we reviewed a number of previously reported methodologies for and approaches to cost-effectiveness analysis of military training options. We also identified in some detail the cost and effectiveness data requirements and data sources for cost-effectiveness analysis of training. Finally, based on the functional requirements from Objective 1 and the candidate methods explored in Objective 2, we developed a training funds decision methodology (TFDM) to support the DoD-level training policy-maker.

c. Objective 3: Demonstrate the TFDM Using a Sample Case Study

To demonstrate the application of the TFDM we conducted a sample case study in which we addressed the following question: "Should support for computer-based instruction/interactive videodisc technology (CBI/IVD) for electronics maintenance training be increased by a specified amount?" The product of this scenario-driven case study was a preliminary evaluation of the TFDM concept, which included diagnostic information for each major step in the process. This modular philosophy was adopted so that fixes could be made to any major step of the TFDM without having to dismantle or discard the entire concept. This low-risk approach to decision support methodology design is based on the concept of rapid prototyping. As such, constructive criticism will continually upgrade the effectiveness of the methodology under development.

B. CONCLUSIONS AND RECOMMENDATIONS

The utility of the TFDM lies in its inherent objectivity and reliability. The TFDM will provide the training policy-maker with a systematic, auditable, data driven methodology that is comprehensive enough to serve his current functions and flexible

enough to accommodate planning, programming, and budgeting changes. The TFDM will provide the training policy-maker with a set of flexible, comprehensive rules to guide his decision process concerning the type, amount, medium, and mix of training that is best for the military today. These rules will help assure that policy justifications are derived from cost and effectiveness data as well as past experience. They will also guide the policy-maker to appropriate, existing training cost and effectiveness data bases. If the required data or data bases do not exist, the TFDM will assist the training policy-maker in specifying the design characteristics of the necessary information repositories. In theory, justifications based on a rigorous logic trail and reliable data should be more defensible than those based on subjective preferences.

Another advantage of this decision support methodology is the ease with which people can learn to operate it. Since its processes are objective, repeatable, and open to scrutiny, the TFDM and its outputs can be applied to other spheres of interest. It appears, for example, that the concepts underlying the TFDM may be transferable to other DoD policy-making activities. Finally, and possibly most important, the TFDM can reduce the costs and time associated with the development of training policy. On the basis of these conclusions, we recommend that ASD(FM&P)TP do the following:

- Continue to develop and refine the TFDM moving toward system design and implementation.
- Begin the development of TFDM data bases using past cost-effectiveness analyses.
- Perform additional detailed case studies to validate TFDM and associated data base design and development concepts.
- Establish an organization within OASD(FM&P)TP to oversee and guide the collection of the data necessary to conduct military training cost-effectiveness analyses.

C. REPORT OVERVIEW

In Chapter II we analyze the training policy-making function. In Chapter III, we lay the groundwork for our methodology for cost-effectiveness analysis in support of the training policy-making function, the TFDM, and then present that methodology. In Chapter IV, we present a sample case study in which the TFDM is applied to a training decision involving the application of CBI/IVD technology to electronics maintenance training. Finally, in Chapter V, we provide an overall summary, draw conclusions, and make recommendations.

II. ESTABLISHMENT OF REQUIREMENTS FOR DESIGN OF A TRAINING FUNDS DECISION METHODOLOGY (TFDM)

This chapter reports on the analytic processes used to develop TFDM design requirements. The first subsection provides an analysis of the training policy-making function and describes the mission and functional responsibilities of the Directorate of Training Policy. Next, the role of the training policy-maker is discussed, followed by a statement of the policy-maker's need for high-level training data bases and tools.

The second and third subsections explain the processes underlying the TFDM. A model for converting resources to training products and the Training Management Model are presented and discussed. Then, some relevant aspects of the Canadian Training Management Model are presented, including its information requirements, decision contexts, and efficiency in cost-effectiveness analysis. Finally, the application of a previously proposed training cost-element structure is explained.

In the final two subsections we present a summary of our analysis and the resulting functional requirements for guiding the development of the TFDM.

A. ANALYSIS OF THE TRAINING POLICY-MAKING FUNCTION

1. The Mission and Functional Responsibilities of the Directorate of Training Policy (DTP)

The Directorate of Training Policy (DTP) of the Office of the Assistant Secretary of Defense for Force Management and Personnel [OASD(FM&P)] is responsible for the development of military training policy for the DoD. The DTP is responsible for reviewing Service training policies, programs, and budgets for effectiveness, efficiency, and consistency with DoD policy. DTP is also responsible for providing justification of training programs and budgets to Congress. DTP's functional areas of responsibility include all training of military individuals, crews, and units, to include recruit, specialized skill, flight, professional, and on-the-job (OTJ) training and operational unit training and exercises.

Within this mission, DTP has eight primary functional responsibilities and four enabling responsibilities. The primary functional responsibilities are as follows:

(1) Development of policy for planning and conducting military training.

(2) Development, acquisition, and use of simulators and training devices.

(3) Development of guidelines for computer-based instruction.

(4) Production of the annual Military Manpower Training Report (MMTR).

(5) Support of the Deputy Assistant Secretary of Defense (Military Manpower and Personnel Policy) [DASD (MM&PP)] as chairman of the OSD Steering Committee on Training and Training Technology.

(6) Represent the OASD (FM&P) on the Euro-NATO Training Group.

(7) Perform liaison with National Security Industrial Association (NSIA) and American Defense Preparedness Association (ADPA) activities.

(8) With the Office of the Deputy Under Secretary of Defense (Research and Advanced Technology), co-sponsor and evaluate joint-Service prototype training devices and technology.

The four additional responsibilities are:

(1) Review Service training policies/programs/budgets.

(2) Provide justification for training programs/resources to Congress.

(3) Manage the training-related research program of ASD(FM&P).

(4) Respond to General Accounting Office/DoD Inspector General (GAO/DoDIG) reports on training matters.

Accomplishment of the mission and functional responsibilities is mediated by preserving essential training resources and enhancing training effectiveness through simulation/technology. Other important concerns include, but are not limited to, the operations of the Training Performance Data Center (TPDC) and portability of computer-based instruction/interactive videodisc courseware.

2. Role of the Training Policy-Maker

The role of the DoD-level training policy-maker is to respond to approved national defense needs by providing adequately trained personnel on time and for an acceptable cost. The training policy-maker is positioned at the highest level of the DoD training

management organization. From this position he manipulates the military training system to meet current personnel needs generated by continual analysis of global threats. This is done through the judicious use of budgetary powers to approve, support, and defend or, as required, disapprove and oppose the proposed budgets for particular parts of the training system. The training manager's power to influence the budget is constrained only by the need to respond to training requirements imposed by external forces, such as weapon system development and personnel policies, and the need to respond in a timely and cost-effective manner.

Although training is critical to the proper functioning of the military, advocates frequently have difficulty securing resources in a highly competitive financial arena because it is very difficult to predict quantitatively the benefits of training. Hence, the training policy-maker needs to be able to estimate accurately the impact of training policy decisions on readiness and force effectiveness. If the relationship between the amount and type of training and performance in combat can be quantified reliably, the formulation of training policy will be less subjective and the training manager's ability to compete for resources will be improved.

3. Need for Policy-Level Training Data Bases and Tools for Their Use

As one analyst noted, in recognition of the need to improve the validity and supportability of training resource decisions,

> ...[a] 1982 Defense Science Board (DSB) study group recommended that DOD set up a centralized data and analysis center for the defense training community. The DSB concluded that, while good training data appeared to exist, the information was not always in a form best suited to the needs of training managers. (Sicilia, 1985)

As a result, the Training and Performance Data Center (TPDC) was established and has become a repository for existing data bases and tools of potential value to the training policy decision-maker. In addition, new data bases and analytical software to facilitate their use are currently under development. However, the utility of existing and planned data repositories to the training policy-maker is not presently clear. This is in part because the data bases and analytical tools have not been developed with a top-down view toward supporting the particular needs of the DoD training policy-maker. In addition, the TPDC has had to serve the needs of a diverse group of users, many of whom have little interest in the data requirements and analysis needs of the DoD-level training decision-makers.

In recognition of this need, IDA's Macro-Level Training Task was designed to:

(1) Provide an overview of the kinds of data available and their relevance to training management issues and to the development of macro-level training data bases.

(2) Identify the data required to evaluate several illustrative and representative policy-making situations.

(3) Collect and evaluate the data required for prototype policy-making situations to demonstrate the range of policy decisions that can be supported by the Macro-Level Cost Data Bases.

The present paper, together with two previous reports, was produced to fulfill these objectives. The first report was entitled, *Macro-Level Training Data: A Conceptual Model Relating Training Cost and Effectiveness Data to Training Policy Interests and Issues* (Gibson and Orlansky, 1988). It developed a conceptual model of the training system from the training manager's perspective. Based on the model and a summary of the available data, some strategies and options for developing the required data bases were presented.

The second paper in this series entitled *Macro-level Training Case Study--Computer Based Instruction/Interactive Videodisc (CBI/IVD) Data System--Phase I Report*, (Gibson et al., 1989) documented the first phase of the analysis. Its goal was to determine the types of data required and to assess the adequacy/availability of these data using a case study approach. The study team developed a representative training policy question, "Should support for computer based instruction/videodisc technology (CBI/IVD) be increased or decreased and, if so, by what amount?" and attempted to answer it using available data. This effort addressed the second and third analytical objectives above.

The present report emphasizing a "rapid prototyping" approach to training policy development is designed to do the following:

(1) Analyze and understand the training policy decision-making function, including its data requirements and analytical process needs.

(2) Develop a concise statement of a Training Funds Decision Methodology that is the practical embodiment of the training policy decision-making function analyzed above.

(3) Conduct two versions of a case study which seek to apply the methodology as defined above.

(4) Draw conclusions concerning the data needs of the training funds decision process vis-à-vis existing data and currently planned data bases.

B. EFFORTS TO MODEL THE MANAGEMENT OF TRAINING

1. A Model for Conversion of Resources to Training Products

As discussed earlier, the DoD training manager manipulates the military training system by converting an objective, tangible quantity (money) into a relatively subjective, intangible quality (combat readiness). From the DoD training manager's point of view, money is the common denominator for support of the various components of a training system. It represents training resources such as student and instructor time, training facilities, and equipment. The process of converting resources into training activities and products is schematically represented in Figure II-1. As part of the process, the training system produces voluminous data related to the consumption of resources and the production of trained personnel.

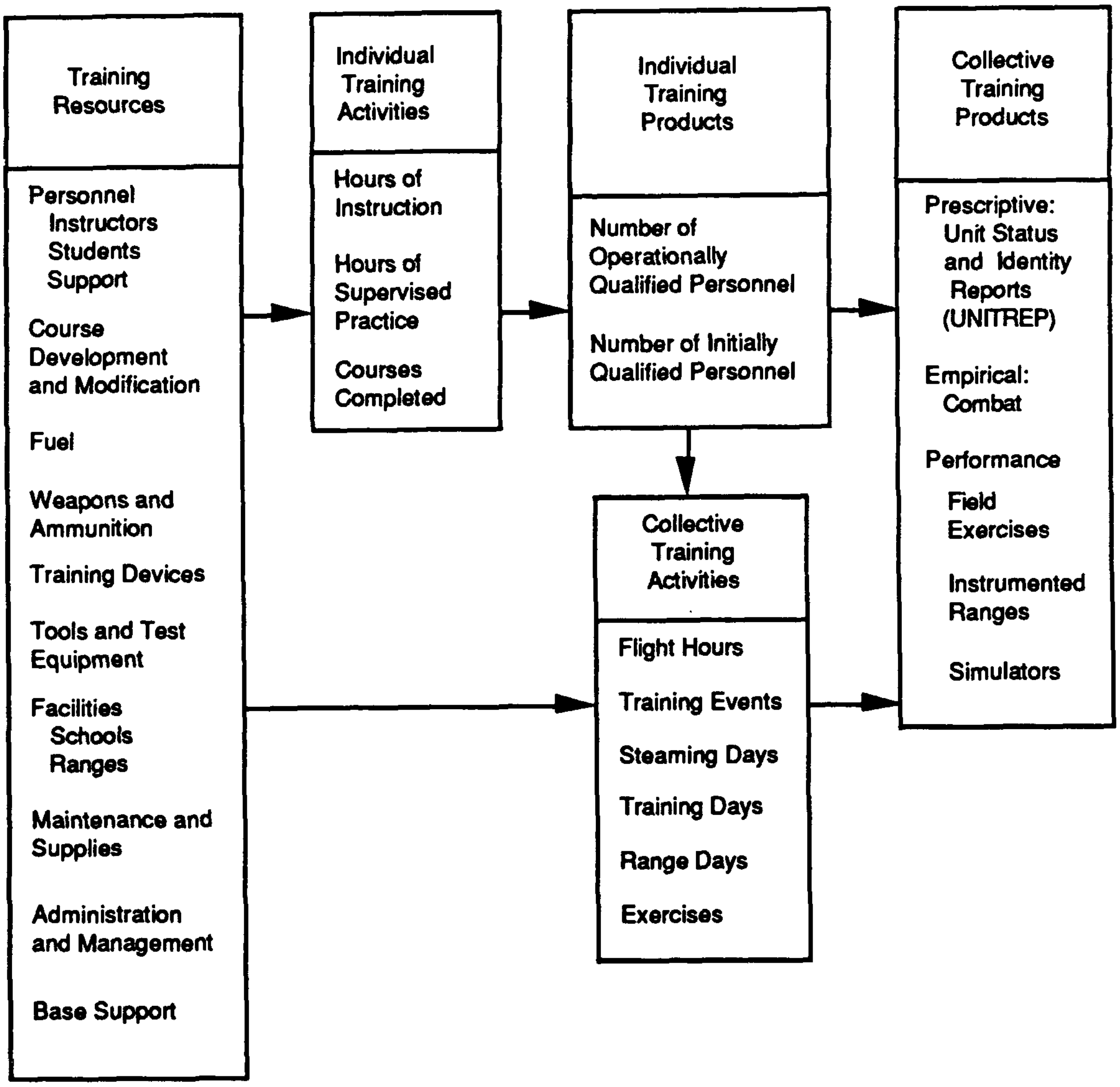
Gibson and Orlansky (1988) identified a clear link between the requirements generated by technical/organizational systems and the resulting training products that should make it possible to use the training data bases for formulating and supporting policy decisions in a precise and quantitative manner. To help identify the data critical to management of the training policy-making process, Gibson and Orlansky developed a Training Management Model (TMM). This model assumes that resources used for training (such as aircraft, ships, tanks, or weapons) are not available for other Service needs. The fundamental principles of the TMM are elaborated below.

2. The Training Management Model

The Training Management Model (TMM) is discussed in terms of its basic dynamics and components, including its cost-production function, performance effectiveness function, and readiness evaluation function.

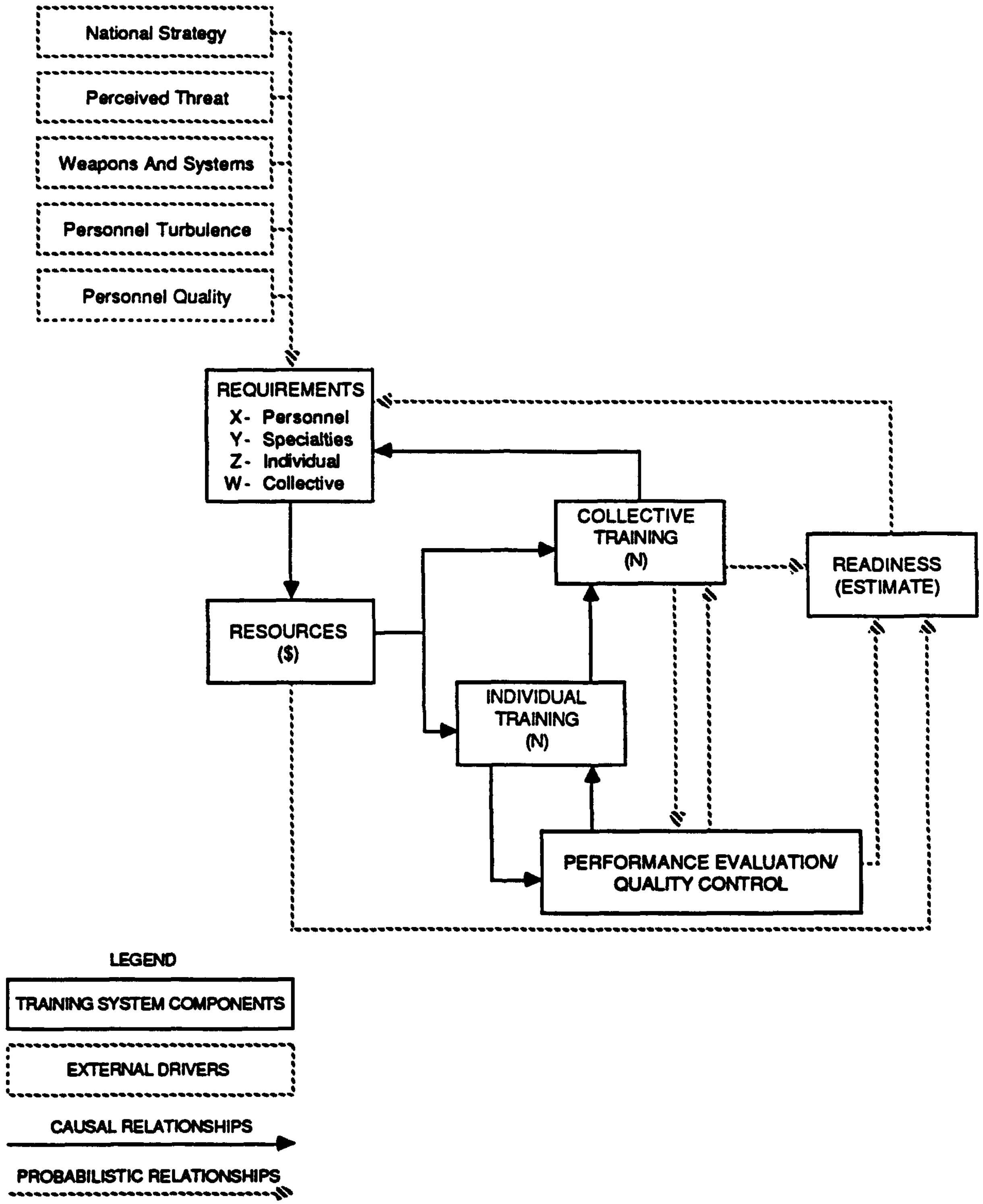
a. Basic Dynamics

The underlying assumption of the TMM is that the military training system is driven by requirements. The requirements in turn are based on national strategy, perceived threat, the character and needs of present and projected platforms and weapon systems, and the quantity, quality, and turbulence of personnel. Figure II-2 shows the relations between those requirements and resources, training activities, performance, evaluation/quality control, and readiness status. This complex of external and internal factors serves to establish the amount of training needed and the composition of the training system.



Source: Gibson and Orlansky, 1988.

Figure II-1. The Conversion of Resources Into Training Activities and Products



Source: Gibson and Orlansky, 1988.

Figure II-2. Training Management Model

Training resources are allocated, and the needed individual and collective training programs are conducted to maintain the quality and quantity of trained personnel established by the requirements. The results of the training provide feedback which also serves to modify the requirements.

> Training requirements are determined by estimating the probable future attrition of required levels and skill mix of personnel due to completion of enlistments, retirements, and the need for increases in personnel levels due to increases and/or changes in weapon systems and force structures. (Solomon, 1986)

b. Structural Components of the Model

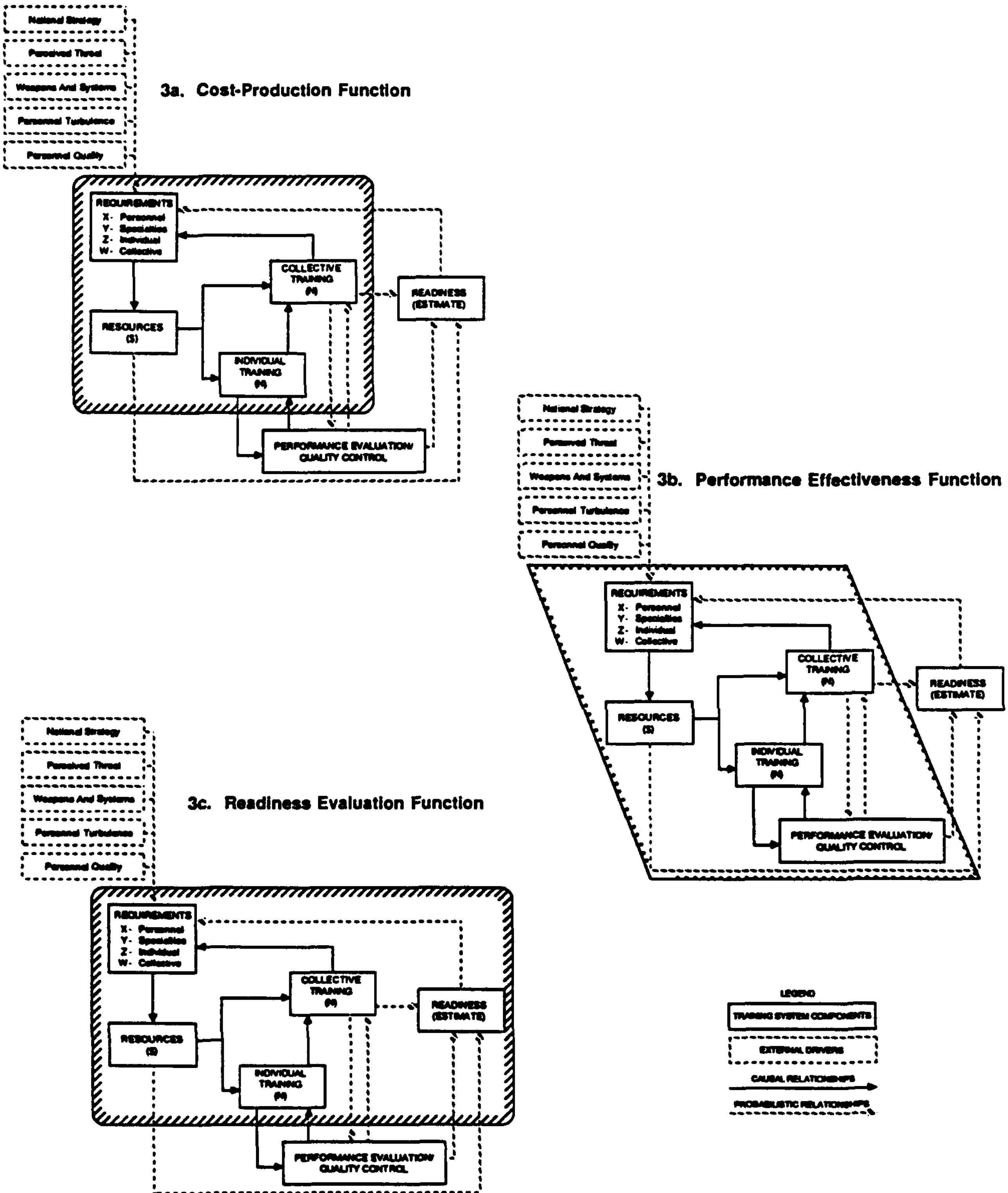
The DoD training manager must be concerned with three major functions addressed by the training system: the cost and production aspects of training; the effectiveness of training; and the level of combat readiness resulting from training.

These three major training management functions in the TMM (Fig. II-3) represent alternative ways that the DoD training manager interacts with the training system. The basic functioning of the overall training system does not change as the manager's orientation and data needs change to respond to various specific problems.

Cost-Production Function. The Cost-Production function is a subset of the TMM elements that describe the normal or baseline operation of the training system. This is represented in Figure II-3a by a continuous feedback loop consisting of the following four elements: Requirements, Resources, Individual Training, and Collective Training. Based upon approved sets of requirements, resources in the form of budgets, facilities, and personnel are channeled into individual and group training programs which ultimately fulfill or modify the existing requirements.

The Cost-Production function is primarily quantitative in nature. It responds to the training manager's concern with costs and the ability of the training system to produce the numbers of trained personnel needed to meet approved organizational requirements on schedule and within budget. This is the standard operating condition of the training system except when it fails to provide an acceptable product in terms of the quantity and quality of trained personnel. The bulk of the training manager's information requests will be generated from within this functional module of training system operation.

The ability of the training manager to operate in the Cost-Production function of the TMM depends upon two assumptions:



Source: Gibson and Orlansky, 1988.

Figure II-3. Training Management Model Functions

- That the training courses and events are effective in conveying the necessary information and skills to the personnel involved, and
- That trained personnel, teams, and units advance the state of readiness and potential combat effectiveness of the armed forces.

When these assumptions have questionable validity, the training manager needs to validate the assumptions empirically with appropriate performance or readiness data.

Performance Effectiveness Function. The Performance Effectiveness function of the TMM supplements the Cost-Production function in two ways. Within training courses, individual performance data (e.g., test scores) support the training quality control process and provide the basis for deciding whether an individual should continue the next phase of training, graduate, recycle, or leave the program. Data on group performance in weapon systems (training or operational) provide a basis for evaluating the effectiveness of training courses or techniques.

The Performance Effectiveness function in Figure II-3b consists of Requirements, Resources, Individual Training, Collective Training, and Performance Evaluation/Quality Control. There is continuous feedback between the Individual Training element and the Performance Evaluation/Quality Control element. However, only an intermittent feedback is represented between Collective Training and the Performance Evaluation/Quality Control element. This function is concerned primarily with the ability of the individual trainees to perform well on the job. Therefore, it provides data on the quality of training or, more specifically, on the quality of the performance skills of trained personnel.

Data on performance effectiveness (test scores or job performance evaluations) can have a dramatic impact on training policy; however, most of these data needs are formulated and the resulting data are collected and used at the individual training (micro-) level where they have minimal direct impact on policy-level decision-making. A positive relationship between training and readiness and potential combat effectiveness is implicitly assumed. When this link is questioned, the training manager needs to collect readiness information to validate this assumption.

Readiness Evaluation Function. This third function of TMM operation looks at the quantitative and qualitative effects of training on combat readiness. Readiness criteria can range from a certification that the approved training requirements have been met to an actual measure of combat-relevant performance. The outcomes from these operations are capable of having a significant impact on the operation of the training system. However,

once a problem has been resolved satisfactorily, the training system goes back to the baseline operating condition represented by the Cost-Production function.

The Readiness Evaluation function, like the Performance Evaluation function, estimates the collective performance capability of operational units and can operate in two distinct ways. The first is represented in Figure II-3c by Requirements, Resources, and Readiness. These three elements provide continuous evaluation of how well the prescriptive readiness requirements have been met, i.e., have all the individuals and functional units completed the required training courses and events? The second way of functioning uses all the elements in Figure II-3c and provides a possible link between training and empirical readiness evaluations.

c. Summary of the TMM

The TMM provides a conceptual model of the major interactions between the DoD training policy-maker and the military training system with respect to the related issues of cost, effectiveness, and readiness due to training. Based on a small set of assumptions about the function and goals of the training policy-maker and the nature of military training, the TMM provides a broad perspective of the types of data most likely to be required to resolve training-policy questions.

All functions of Cost Production, Performance Effectiveness, and Readiness Evaluation may operate at the same time. The ones that are emphasized depend on what training issues are dominant at that time. The Cost-Production function is the normal operating condition. Here, the DoD training manager is primarily concerned with costs, the effectiveness of the training system in providing the mix of trained personnel required, and ways to minimize the cost of providing trained personnel.

If the effectiveness or cost-effectiveness of a specific training effort becomes questionable, then the performance effectiveness of the training system becomes the dominant concern. Here, performance data, primarily on individuals or groups in training or recently graduated from training, should be examined by the training manager. If the contribution of training to combat readiness is questionable, then the readiness evaluation aspect of training becomes dominant. In this case, the focus of the manager's interest may be either the adequacy of the training system in providing all the courses and unit training events required for combat readiness or how well the courses and unit training events contributed to some measure of combat effectiveness. When questions concerning

performance effectiveness or readiness evaluation have been answered, the emphasis reverts back to the cost-production aspect of training.

From the perspective of the DoD training policy-maker, the most interesting data will be what resource expenditure on a particular training approach is likely to produce a specific, measurable increase in performance. To achieve these data, it will be necessary to precisely quantify performance gains resulting from the application of a training resource. Therefore, for the purpose of this report, the essential features of the TMM are its cost-production and performance effectiveness functions.

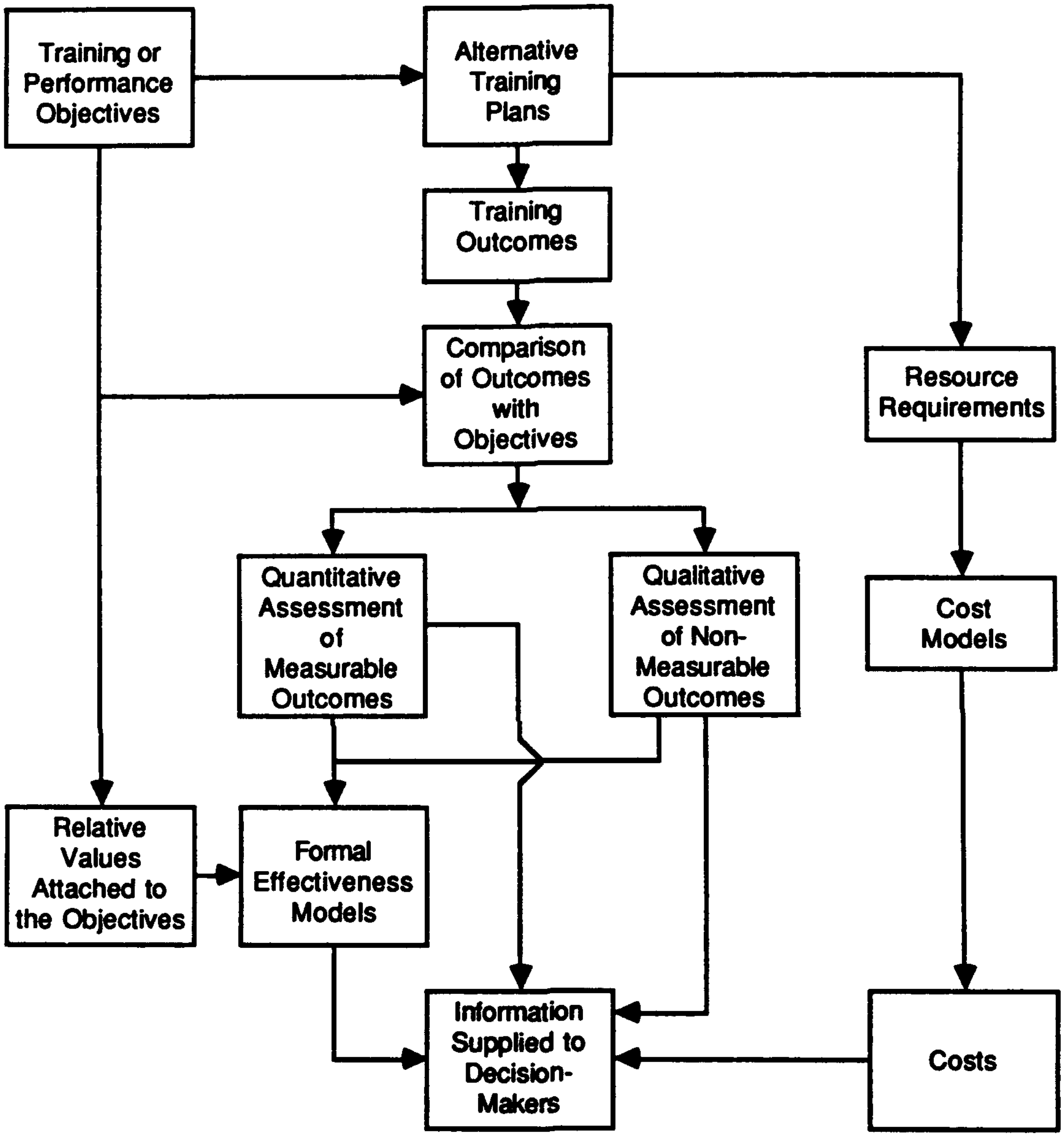
3. The Canadian Training Management Model

In November 1987, the Bureau of Management Consulting for Supply and Services, Canada, prepared a draft report for the Directorate of Research and Development (Human Performance) of the Department of National Defense entitled "Issues in Cost-Effectiveness Analysis of Military Training." The report included discussions of information linkages in cost-effectiveness analysis of training, the context of the training decisions that the cost-effectiveness analysis is meant to support, and the evolution of cost-effectiveness data for training decisions.

a. Information Linkages

The key elements and information flows involved in the Canadian cost-effectiveness analysis of training are illustrated in Figure II-4. First, performance objectives are derived from an analysis of the requirements of the job or the tasks for which the training is to be conducted. Alternative training approaches are then formulated to meet the specified objectives. The plans may vary with respect to such factors as the method of delivery (e.g., self-paced versus group), the duration of training, location of training (e.g., school versus on-the-job), and the type of equipment used (e.g., simulation versus actual equipment). The resources required to implement each alternative are identified and costed. This will normally require the use of a standard cost model to provide a fair comparison of the costs of the various alternatives. The cost information is then supplied to the decision-maker. Therefore, this portion of the Canadian model is much like the Cost-Production function of the TMM.

The various outcomes of the alternative training plans are then determined and assessed with reference to the training objectives. These outcomes are usually a measure of



Source: BMCSS Canada, 1987.

Figure II-4. Information Linkages in Cost-Effectiveness Analysis of Training

the ability of the trainee to perform specified tasks or to demonstrate required knowledge after completion of the training. The outcome assessments may be quantitative or qualitative, depending upon the nature of the task involved. Quantitative assessments require direct measurement of outcomes, usually with respect to some specified standard of performance. Qualitative assessments require the use of experienced umpires or observers. The objectivity of qualitative assessment can be enhanced, and the effects of individual bias minimized, if clearly defined evaluation procedures and criteria are established first. Table II-1 provides a general indication of the types of tasks for which quantitative assessment may be possible and contrasts them with tasks for which some degree of qualitative assessment is likely to be unavoidable. This portion of the Canadian model mimics the Performance Effectiveness Function of the TMM. The Canadian model does not distinguish between performance and readiness as concepts requiring separate evaluation.

Table II-1. Relationship of Task Characteristics to Method of Training Outcome Assessment

Method of Assessment	
Quantitative	Qualitative
Many individual tasks	Many collective tasks
Well-structured tasks	Poorly structured tasks
Tasks undertaken in a specified and controlled environment	Tasks involving the ability to respond to an uncertain environmental stimulus
Basic procedural tasks	Tasks requiring considerable cognitive skill

Source: BMCSS Canada, 1987.

The assessment information, both quantitative and qualitative, may be supplied to the decision-maker who is then in a position to determine which training plan is the most cost effective. This cost-effectiveness determination may be quite complex, especially if the decision-maker is faced with a large array of outcome assessments for each alternative. However, just as resource costs may be rationalized through the use of cost models, so elements of effectiveness can be rationalized through the use of formal effectiveness

models. The Canadian model makes the role and function of the decision-maker more explicit than the TMM.

b. Decision Context

The authors note that in any cost-effectiveness analysis of military training, the cost elements and effectiveness measures considered will depend largely on the context of the training decision which the analysis is intended to support. In Table II-2, the authors present a tentative general framework to illustrate this point. The cost elements are presented in a highly aggregated form, and effectiveness is identified in terms of levels (related, in part, to the hierarchy presented in Figure II-5), rather than specific measures. An actual analysis would require the identification of a much more detailed list of cost elements within the categories indicated and a range of specific effectiveness measures at the levels indicated.

In Table II-2, nine decision contexts or situations have been selected. Other possible contexts could have been included by the authors, but the nine chosen represent a broad range of options with respect to the cost elements and effectiveness levels considered. In each case, those cost elements that are required for the analysis are indicated with an "X". In some decision contexts, effectiveness is also allowed to vary and may be considered endogenous. In other cases, the focus of the decision is on finding the most efficient way of reaching a fixed effectiveness standard [indicated with an "(X)"]. An endogenous variable is one which is allowed to vary in the analysis in response to the decision being made. An exogenous variable, on the other hand, is either assumed to be uninfluenced by the decision or to be beyond the scope of the analysis. Each of the nine decision contexts is discussed below.

1. *Methodological Evaluation.* The evaluation of a new method of instruction for teaching a given course in a given location would probably be concerned only with initial investment and direct operating costs. Since the method would already have been developed, no R&D would be required, while support and infrastructure costs would be common to all alternatives being considered. It is likely that the decision would be based on relative efficiency in attaining the existing performance objectives of the course.

2. *Instructional Development.* The second case involves a broadening of the decision context in two ways. First, since the decision involves the development as well as the implementation of a new method of instruction, the R&D costs would have to be taken into account. Second, if the new method

Table II-2. Relationship Between Decision Context, Cost Elements, and Effectiveness Levels

	Decision Context								
	Evaluation of new method of instruction for course	Development of new method of instruction (e.g., CAL)	Evaluation of new simulator developed elsewhere	Occupational Analysis	Evaluation of training organization	Research into specific training problems	Design of equipment incorpo-rating training considerations	Trade-off between training and operational considerations	Overall assessment of maintenance training
COST ELEMENTS Individual Course (total)					X				X
Research and Development		X					X	X	
Initial Investment	X	X	X				X	X	
Direct Operating	X	X	X				X	X	
Support		X	X				X	X	
Training Infrastructure					X				X
Training Research									
Specific						X			X
General									
EFFECTIVENESS LEVELS Attainment of Course POs	(X)	(X)		X	X		X		X
Individual on-the-job skill (with existing equipment)			X	(X)	(X)	X			X
Combined man/machine performance (new or modified equipment)							X		
Collective unit performance								(X)	
Equipment readiness									X
Overall military preparedness									

X = endogenous variable

(X) = exogenous variable used as reference point

Source: BMCSS Canada, 1987.

	Levels	Performance Criterion	Some Additional Factors Affecting Performance at this Level
Increasing difficulty in determining training impact on performance ↓	1.	Extent of individual attainment of POs at end of course	• individual characteristics • previous training
	2.	Individual performance within context of unit	• aspects of unit environment affecting transfer of training, skill enhancement, and skill decay
	3.	Ability of unit to accomplish mission	• manpower • abilities of other unit members • equipment characteristics • motivation/cohesion • tactics
	4.	Ability of command to accomplish mission	• abilities of other units • logistics • strategy

Source: BMCSS Canada, 1987.

Figure II-5. Impact of Specific Training Course on Performance at Various Levels

involves different methods of instructional delivery (e.g., remotely delivered versus centrally delivered classroom instruction), then support costs may well be affected.

3. *Simulator Evaluation.* The evaluation of a previously developed simulator will involve consideration of investment and operating costs, but, since the decision may involve comparisons with training on actual equipment, support costs will also allow for the possibility that the simulator might be more effective than actual equipment in training certain tasks (e.g., tasks which, if performed with actual equipment, would be too dangerous or too expensive). Thus, in this case, the effectiveness measures are treated endogenously.

4. *Occupational Analysis.* An occupational analysis might not be concerned with cost at all. Such an analysis would focus on the determination of tasks and associated performance objectives dictated by on-the-job requirements.

5. *Organizational Evaluation.* An evaluation of the way training is organized would focus on the costs of the training infrastructure and the extent to which it meets job requirements. In such an analysis the costs of individual courses would probably be considered only in aggregate.

6. *Training Research.* An analysis of research into specific training problems would be concerned primarily with specific training research costs and the extent to which such research might lead to improvement in existing on-the-job skills.

7. *Equipment Design.* One aspect of the design of new weapon systems (and other equipment) is the ease with which personnel can be trained to operate and maintain the system. A cost-effectiveness analysis in support of such design decisions would be likely to involve all aspects of training delivery and the determination of appropriate performance objectives for the tasks identified. Overall effectiveness in this case would be determined at the level of combined performance of man and machine in order to identify appropriate trade-offs between design and training aspects.

8. *Trade-Offs.* At a more general level, decisions might be made regarding the appropriate mix of training and operational resources required to enable a unit to achieve a given level of effectiveness. As with the previous case, all elements of training course costs would be involved. However, the focus of effectiveness assessment would be at the unit level.

9. *Maintenance Training Assessment.* Finally, an overall assessment of maintenance training would be concerned mostly with infrastructure costs and training research specific to maintenance problems. Individual course costs would probably be considered only in aggregate. The overall determinants of maintenance training effectiveness would probably be measures associated with equipment readiness. It is likely, however, that such readiness would be linked to on-the-job skills and associated training performance objectives. Finally, the authors note that the major cost involved in conducting cost-effectiveness analysis is in acquiring and processing the data involved.

C. EFFICIENCY IN COST-EFFECTIVENESS ANALYSIS

Not only is the Canadian approach to cost-effectiveness analysis markedly similar to our TMM, but the problems anticipated and encountered in its application are virtually identical. The Canadians suggest that such problems may be minimized, and the analytical process made more efficient, by ensuring that information and results obtained from the model are understandable and accessible immediately to the decision-maker. In this way, duplication of effort is avoided and learning from experience is promoted.

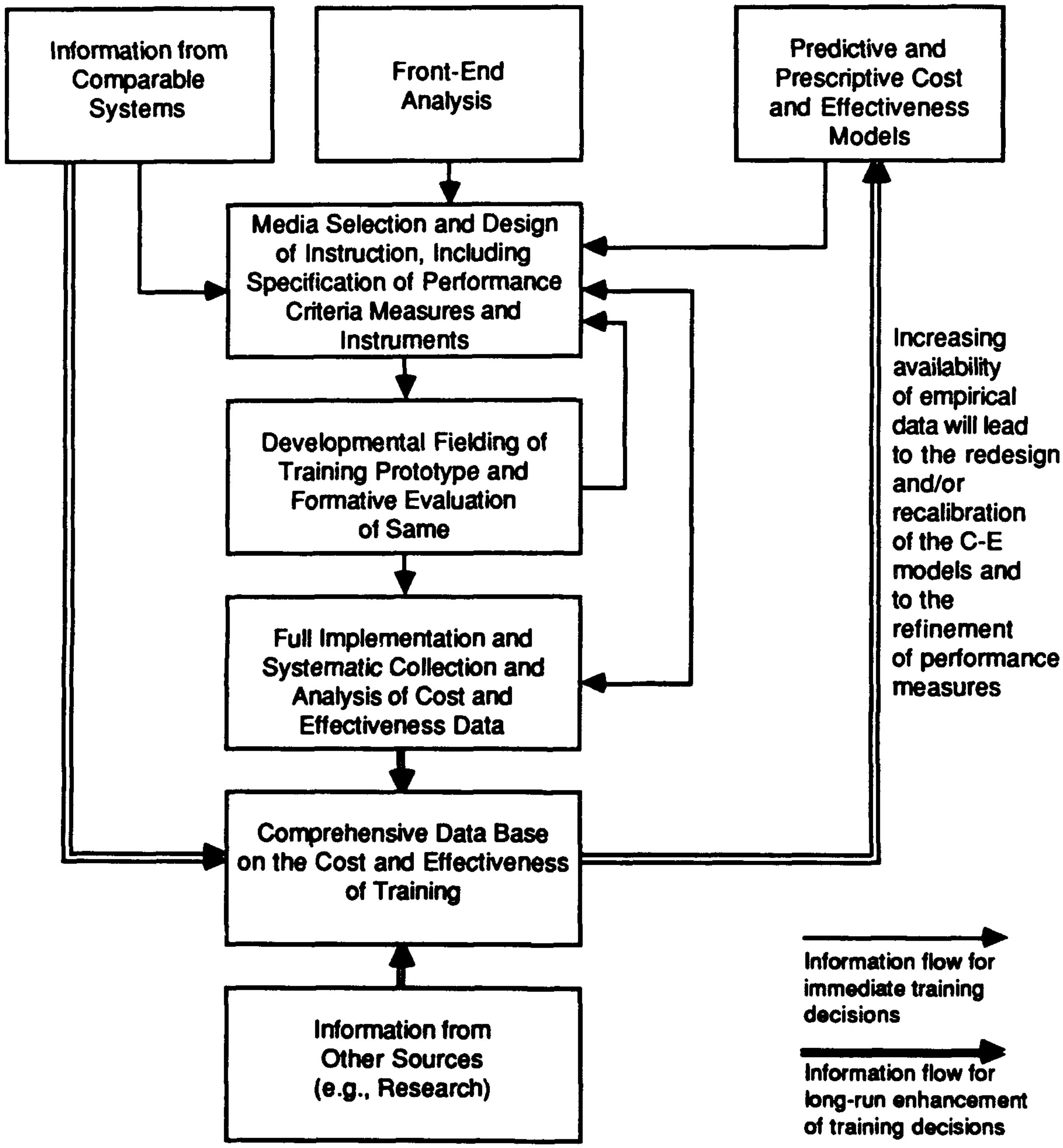
The Canadians concluded that the most effective way of preserving model output information would be to set up a comprehensive data base on the costs and effectiveness of training. Figure II-6 illustrates the mechanism through which they believe such a data base might evolve. First, the information flows for immediate training-related decisions are

illustrated. Front-end analysis is conducted to determine the task structure of the job for which training is required and to define appropriate performance objectives. This information is then used in conjunction with predictive and prescriptive cost and effectiveness models and, where available, information from comparable systems in order to design the course and select appropriate media for instruction. Formative evaluation of the course during development may lead to design modifications. Finally, as experience is gained with the course in full operation, further design modifications may occur.

As we have learned in the United States, the information generated by this process should not be lost. Following implementation, the Canadians suggest that cost and effectiveness data gathered and analyzed for summative evaluation of the course should be fed into their proposed comprehensive data base. If information from comparable systems was used in the design of the system, then they suggest that this too should be made part of the data base. In addition, the data base can be further enhanced by including information from other sources, such as research on generic training issues. As illustrated in Figure II-6, it will, among other things, facilitate the refinement of predictive cost-effectiveness models and the enhancement of performance measures. The net result should be that more effective use is made of the training budget and of available training time.

To implement and maintain such a repository, von Baeyer (1985) has suggested establishing a central and impartial organization to conduct training cost-effectiveness analyses. The concept of such an impartial evaluative body has not been seriously proposed in the United States. Here, the analyses themselves seem to be left primarily in the hands of those concerned with the training issues and only the data bases have received serious attention in terms of their organization in a central repository, TPDC.

The Canadian model lends credence to our own TMM. However, its authors have judiciously left the complex issue of readiness out of the model, focusing primarily on performance as a measure of training effectiveness. As previously noted, they have more explicitly represented the role and functions of the training resource manager (policy-maker) and made more explicit reference to the options that must be evaluated. They have explicitly provided us with nine different decision contexts and briefly analyzed the varying requirements of each for cost elements and effectiveness levels (measures) in analyzing each. These will prove valuable in our case study. Finally, the Canadians have suggested a mechanism for predicting the evolution of cost-effectiveness data (and models) for training decisions, something that should no doubt be our ultimate goal as well.



Source: BMCSS Canada, 1987.

Figure II-6. Evolution of Cost-Effectiveness Data for Training Decisions

D. APPLICATION OF A PROPOSED COST-ELEMENT STRUCTURE TO TRAINING PROGRAMS, COURSES, AND DEVICES

A careful consideration of all potentially useful elements of training cost is critical for proper and optimal performance of the training policy-making function and will be essential in our later specification and trial application of the Training Funds Decision Methodology. Knapp and Orlansky (1985) prepared Table II-3 to illustrate the applicability of each cost element in their previously developed cost element structure (CES) for defense training including academic, maintenance, and flight training. Each type of training was evaluated in previous studies (i.e., the cost-effectiveness of flight simulators, computer based instruction, and maintenance simulators). Discrimination between military and civilian personnel, although an important characteristic of the CES, was omitted from Table II-3 because it was not essential to illustrate its general applicability. The applicability of each cost element to each type of training was then estimated as indicated in the legend appended to Table II-3.

Knapp and Orlansky found that some instructional functions and the costs associated with them are essential to all training systems regardless of their size, development status, or complexity. Therefore certain costs would always be incurred. These costs include program/course/device (p/c/d) design, test and evaluation, system/project management, instructional materials, initial training of instructors, base operations, and management/support personnel.

Additional functions and resources, specific to new training programs, courses, or devices are also required. For example, initial investment costs associated with hardware and software production apply to simulators and aircraft designed exclusively for training, but they are not applicable to conventional and individualized instruction in which computers are not utilized.

Although the assessment of degree of applicability in Table II-3 was partially judgmental, the table shows that a common cost element structure can be applied to the broad range of training programs, courses, and devices. As noted at the beginning of this subsection, we will need to consider carefully all potentially useful elements of training cost for inclusion in the TFDM. Knapp and Orlansky (1983, 1985) and the Canadian Bureau of Management Consulting (1987) have presented comprehensive cost element structures that serve this purpose. Once we have combined these with training effectiveness data, in cost-effectiveness analyses, we should be well on our way to prescribing a comprehensive TFDM.

Table II-3. Illustrative Application of the Comprehensive Cost Element Structure for Military Training Programs, Courses, and Devices

Cost Categories/Elements	Academic Training				Maintenance Training		Flight Training		
	Conventional	Individualized	Computer-Based[a]		Actual Equipment	Simulator[a]	Aircraft		Simulator[a]
	No Computers		Computer-Assisted	Computer-Managed			Trainer[b]	Operational[c]	
A. RESEARCH AND DEVELOPMENT									
1. Design	+	+	+	+	+	+	+	+	+
2. Component Development	+	+	+	+	+	+	+	•	+
3. Producibility Engineering and Planning			•	•	•	+	+	•	+
4. Tooling			•	•	•	+	+	•	+
5. Prototype Manufacturing			+	+	+	+	+	•	+
6. Data									
a. Managerial	+	+	+	+	+	+	+	+	+
b. Technical	•	•	+	+	+	+	+	+	+
7. P/C/D Test and Evaluation	+	+	+	+	+	+	+	+	+
8. System/Project Management	+	+	+	+	+	+	+	+	+
9. Facilities			•	•	•	•	•	•	•
10. Other	•	•	•	•	•	•	•	•	•
B. INITIAL INVESTMENT									
1. Production									
a. Nonrecurring									
b. Recurring									
(1) Manufacturing			+	+	+	+	+	+	+
(2) Sustaining Engineering			+	+	•	+	+	+	+
(3) Sustaining Tooling			•	•	•	+	+	+	+
(4) Quality Assurance			•	•	+	+	+	+	+
(5) Other			•	•	•	•	•	•	•
c. Initial Spares and Repair Parts			+	+	+	+	+	+	+
5. Data									
a. Managerial	+	+	+	+	+	+	+	+	+
b. Technical	•	•	+	+	+	+	+	+	+
c. Instruction Materials	+	+	+	+	+	+	+	+	+
10. Initial Training									
a. Instructors	+	+	+	+	+	+	+	+	+
b. Maintenance Personnel			+	+	+	+	+	+	+
11. Transportation									
a. First Destination	•	•	•	•	•	+	+	+	+
b. Second Destination	•	•	•	•	•	•	•	•	•
12. Other	•	•	•	•	•	•	•	•	•
C. OPERATING AND SUPPORT									
1. Direct Costs									
a. Instructional Costs									
(1) Pay and Allowances									
(a) Instructors	+	+	+	+	+	+	+	+	+
(b) Supervisors, Administrative and Support Personnel	+	+	+	+	+	+	+	+	+
(c) Maintenance Personnel	•	•	+	+	+	+	+	+	+
(2) Other Government Personnel Costs	+	+	+	+	+	+	+	+	+
(3) Consumption									
(a) POL					•		+	+	
(b) Training Munitions	•	•			•		+	+	
(c) Utilities									
(8) Other	•	•	•	•	•	•	•	•	•
b. Training Activity Costs									
(1) Pay and Allowances	+	+	+	+	+	+	+	+	+

Table II-3. (continued)

Cost Categories/Elements	Academic Training				Maintenance Training		Flight Training		
	Conventional	Individualized	Computer-Based [a]		Actual Equipment	Simulator [a]	Aircraft		Simulator [a]
	No Computers		Computer-Assisted	Computer-Managed			Trainer [b]	Operational [c]	
c. Airfield and Carrier Operations Costs									
(1) Pay and Allowances							•	•	
(2) Other Government Personnel Costs							•	•	
(3) Other							•	•	
d. Student Costs									
(1) Pay and Allowances	+	+	+	+	+	+	+	+	+
(2) Other Student Costs	+	+	+	+	+	+	+	+	+
e. Other Direct Costs	•	•	•	•	•	•	•	•	•
2. Indirect Costs									
a. Base Operations									
(1) Pay and Allowances	+	+	+	+	+	+	+	+	+
(2) Other Government Personnel Costs	+	+	+	+	+	+	+	+	+
(3) Other	•	•	•	•	•	•	•	•	•
d. Command Support Costs									
(1) Pay and Allowances	+	+	+	+	+	+	+	+	+
(2) Other Government Personnel Costs	+	+	+	+	+	+	+	+	+
(3) Other	•	•	•	•	•	•	•	•	•
e. Other Indirect Costs	•	•	•	•	•	•	•	•	•

[a] Assumes new hardware and/or software.

[b] Designed, produced, and operated as a trainer.

[c] Essentially operational configuration and performance. May be used in primary mission role but used as trainer.

+ Always applicable.

• May be applicable, depending on the context of the problem presented, assumptions, ground rules for the analysis, and characteristics of the training program/course/device of interest.

(Blank) Not applicable.

Source: Knapp and Orlansky, 1985.

E. REQUIREMENTS FOR A TRAINING FUNDS DECISION METHODOLOGY

As we have seen, the DoD training manager reviews Service training policies, programs, and budgets for effectiveness, efficiency, and consistency with DoD policy. On the basis of this review, the training policy-maker provides supporting justification for training programs and budgets to Congress.

In the next section, we develop a prototype training funds decision methodology (TFDM), based upon the mission and responsibilities of the DTP and the role of the

training policy-maker as examined in this chapter. We begin with our concept of a training management model (TMM) as the core of this methodology, supplemented with our knowledge of the relevance of various elements of cost and training effectiveness to different types of training designed to meet varying objectives. The formulation of our methodology was guided by our knowledge of the state of the art of military (as well as nonmilitary) cost-effectiveness analysis, as it applies to the requirements we are seeking to support. Ultimately, we will wish to specify our methodology in terms of process flow diagrams, but we can begin here with the flow of functional requirements for the TFDM.

In later sections of this report, we apply our methodology to two versions of a case study, analyze the data needs of the methodology vis-à-vis available data bases, and suggest future directions for work, including the development of an automated computer tool to support the TFDM.

Based on our analysis, the TFDM will be required to perform five functions which can be described briefly as follows.

1. **Frame the Question.** Based upon the general concerns being raised in the specific training funds decision context, the TFDM must match the current analysis situation with one template or schema chosen from a predefined taxonomy of possible analysis situations.

2. **Make the Options Explicit.** Based upon specific questions and issues, including training or performance objectives, the TFDM must develop alternative training plans. This may require some up-front analysis to ensure adherence to cost and performance constraints.

3. **Determine Costs of Options.** The TFDM must estimate the costs of each training option in all relevant cost categories. This may require the use of a standard cost model to provide a fair comparison of the costs of the various alternatives.

4. **Determine the Training Effectiveness of Each Option.** The TFDM must help to predict job performance productivity/proficiency gains compared to present practice that would result from each training option. In some cases, the research literature may be our best and only source for such data.

5. **Perform Cost-Effectiveness Calculations and Draw Conclusions.** The TFDM must determine the productivity/proficiency gains to be expected per unit cost for each training option and provide conclusions regarding the most desirable option, taking appropriate constraints (e.g., budgetary, time to train) into account.

F. SUMMARY

A number of authors have attempted to capture the essential elements of the policy-making function for military training as performed by the DoD-level training manager. In this section, we define the role of the DoD-level training manager and address the need for macro-level training data bases and tools for their use, after providing a succinct statement of the mission and functional responsibilities of the DTP of the OASD(FM&P)TP.

Based on the firmly identified need for macro-level training data bases and techniques for their use, we laid the foundation for this effort by clarifying its objectives and products. Since we belive that policy is made as the DoD-level training manager converts money into combat readiness, we presented the TMM to show how the training manager does this conversion process. The essential components of this model are requirements, resources, training activities, performance evaluation, quality control, and readiness status. The structural components are the cost-production function, the performance effectiveness function, and the readiness evaluation function.

Next, we reviewed the work of the Canadian Bureau of Management Consulting to augment the work of Gibson and Orlansky (1988) and Gibson et al. (1989). Specifically, we looked at the information linkages in cost-effectiveness analysis of training, which essentially provided us with a Canadian version of our TMM with the role of the decision-maker in evaluating alternatives made more explicit and the concept of readiness not represented in the Canadian model. We went on to focus on the varying nature of the macro-level training decision contexts and how it affects the level of our analyses of both cost and effectiveness elements. Finally, we examined the Canadians' views on providing for efficiency in cost-effectiveness analysis. They take what we in the United States have attempted at TPDC a step further, proposing data bases for integrated cost-effectiveness analysis (not independent cost and effectiveness data bases) and an independent cost-effectiveness evaluation organization to perform all required military cost-effectiveness analyses as an impartial body.

Finally, we returned to a consideration of the cost data elements we must draw upon and how they are conditioned for the type of training under consideration. Careful consideration of the appropriate cost categories and elements will be critical for the success of the training funds decision process and the supporting training funds decision methodology.

III. A METHODOLOGY FOR COST-EFFECTIVENESS ANALYSIS IN SUPPORT OF TRAINING POLICY

In this section we describe a methodology for cost-effectiveness analysis in support of policy-making for training. First, we review a number of previously reported methodologies for cost-effectiveness analysis of military training options. Next, we identify in some detail the training cost and effectiveness data requirements and data sources for cost-effectiveness analysis of military training options. Finally, drawing upon earlier material, we present our own Training Funds Decision Methodology (TFDM) in support of the DoD-level policy-maker for training.

A. PREVIOUS METHODOLOGIES FOR COST-EFFECTIVENESS ANALYSIS OF MILITARY TRAINING

In this subsection we review seven previously published studies, all of which focus on the use of methodologies for cost-effectiveness analysis of military training. Several of these studies are themselves lengthy reviews of other cost-effectiveness studies. The purpose here is to lay both a theoretical and pragmatic foundation for what is to follow, based upon a recent history of such analyses.

1. Cost and Effectiveness of Computer Based Instruction (Orlansky and String, 1979)

Orlansky and String (1979) evaluated the cost and effectiveness of computer based instruction (CBI) for military training on the basis of 30 studies conducted since 1968. Computer assisted instruction (CAI) and computer managed instruction (CMI) were found, on the average, to save approximately 30 percent of the time required by students to train conventionally. Cost savings attributed to CAI and CMI in the various studies were based on estimates of pa_ and allowances of students for the time saved by these methods of instruction. The authors found that allowances were seldom made for the costs of the CAI or CMI equipment and courseware, instructors, and other costs incremental to computer based instruction. No cost-effectiveness analyses could be performed by the authors for lack of the proper data, even though many of the original studies had purported to support the cost-effectiveness of computer based instruction.

2. Cost-Effectiveness and Maintenance Simulators (Orlansky and String, 1981)

Orlansky and String (1981) evaluated the cost-effectiveness of maintenance simulators, compared to actual equipment trainers, for training military maintenance technicians. They first sought to establish the effectiveness of maintenance simulators versus actual equipment trainers when measured by student achievement at school and according to supervisors' ratings of the job performance of students trained either way. They found no significant differences in training effectiveness. Next, they sought to establish the relative acquisition costs of the two alternatives. They found that the acquisition cost of maintenance simulators is typically less and that the life cycle cost of maintenance simulators over a 15-year period would cost 40-60 percent as much as actual equipment trainers, according to a life-cycle cost comparison. Based on these data, they concluded that maintenance simulators are a cost-effective alternative compared with actual equipment trainers.

3. Framework for Evaluating the Cost-Effectiveness of Military Equipment and Procedures (Chatelier et al., 1985)

Chatelier, Harvey, and Orlansky (1985) provided a framework for evaluating the cost-effectiveness of equipment and procedures used in military training. In their work they suggested the use of the Transfer Effectiveness Ratio (TER) proposed by Roscoe (1971, 1972). The TER equals the time required to reach criterion performance using actual equipment without prior use of a simulator (A), minus the time required to reach criterion performance using actual equipment with prior use of a simulator (AsubS), divided by the time spent training in the simulator (S) [TER = (A–AsubS)/S]. A TER of greater than one indicates that total training time (actual time plus simulator time) decreases for the tasks practiced on the simulator. They also supported the use of the Training Cost Ratio (TCR) which is the ratio of the cost of the new training approach (simulator) to the cost of the existing training approach (actual equipment). A TCR of less than one says that the new training approach (simulator) is cheaper than the old one.

Finally, they used the Cost Effectiveness Ratio (CER), i.e., the TCR divided by the TER. If this ratio is less than one, then the new approach is more cost-effective. For example, Chatelier et al. (1985) report that flight simulators save about 50 percent of the time needed by pilots to train in aircraft and cost only 12 percent as much to use. This means a CER of 0.24, which says that one additional unit of proficiency achieved with simulators was only 24 percent as costly as one achieved with the actual equipment. It is

clear that flight simulators are extremely cost-effective, compared to the use of aircraft alone for training.

4. Cost-Effectiveness of Military Training (Orlansky, 1985)

In a review of studies addressing the cost-effectiveness of military training, Orlansky (1985) concluded that flight simulators, CBI, and maintenance training simulators are as effective as aircraft, conventional classroom instruction, and actual equipment, respectively. Data from approximately 100 studies were reported to support this finding. Orlansky noted that these methods of training save student time, investment costs, and operating costs in the case of flight and maintenance simulators. Credible cost data were not available for CBI at that time. Orlansky used the arguments of equal effectiveness at less cost and greater effectiveness at equal cost to support the claim of greater cost-effectiveness of CBI and simulators.

5. Model of Cost/Effectiveness Analysis of Training Devices (von Baeyer, 1985)

Von Baeyer (1985) presents a very comprehensive model for cost-effectiveness analysis of training devices. The model's goal is to enable the training procurement officer to predict, and the user of training devices to evaluate and monitor, the cost and training effectiveness of training devices. The comprehensive cost-effectiveness model consists of five submodels to perform media selection, assessment of effectiveness, estimation of costs, cost-effectiveness trade-offs, and device evaluation. Each submodel is discussed briefly in turn below.

a. Media Selection

Submodel 1 produces media alternatives for training devices which first undergo a rough cost-utility analysis. It is applicable as early as the "concept phase" of the weapons system development cycle, when training concepts must be formulated.

b. Assessment of Effectiveness

Submodel 2 consists of a taxonomy of functions and measures of the effectiveness of training devices. The purpose of Submodel 2 is to predict in detail the effectiveness of alternate training devices. It is applicable when specific technical, tactical, and logistics data of the weapons system are available, so that training concepts can be formulated and training devices can be developed.

c. Estimation of Costs

Submodel 3 is a life-cycle cost-planning model containing a cost breakdown structure, computing rules, and rough planning figures.

d. Cost-Effectiveness Trade-offs

Submodel 4 relates the specific effectiveness of alternative training devices to life-cycle cost predictions. Its purpose is to compare training effectiveness with cost development and to identify cost drivers as well as minimally effective improvements.

e. Device Evaluation

Submodel 5 monitors cost-effectiveness during the in-service phase of the training device evaluation and produces data which can be used as an "audit trail" for better predictions and further decisions. It is included in this comprehensive model to ensure that early predictions and post hoc analyses use the same conceptual framework and methodology.

We believe this model to be the most comprehensive we have encountered in our review of the training cost-effectiveness literature. However, it is much too detailed and data-intensive for use by the DoD-level decision-maker for training policy.

6. Economic Issues in Cost-Effectiveness Analysis of Military Skill Training (Solomon, 1986)

Solomon (1986) addressed the economic issues in cost-effectiveness analyses of military skill training making two important points relevant to TFDM development: 1) if there is more than one way to achieve an objective, specified as a particular level of output and/or effectiveness (performance), the least-cost alternative should be identified; and 2) if there is a budgetary constraint, there should be a way of selecting the alternative that will result in maximum output and/or effectiveness. The author introduces two notions of Sassone (undated), the Compensating Budget Variation (CBV) and the Equivalent Budget Variation (EBV), each defined as follows:

- The CBV is the maximum reduction in the training budget that will maintain the current level of training effectiveness if the new type of training is introduced, and
- The EBV is the minimum increase needed in the training budget to achieve the same effectiveness level without the new training.

Solomon and Sassone's ideas about conducting cost-effectiveness analyses are consistent with one another and with those presented by the other authors reported on here.

7. Empirical Studies on Cost-Effectiveness of Military Training (Fletcher and Orlansky, 1989)

Fletcher and Orlansky (1989) summarized 22 recent, empirical studies on the cost-effectiveness of military training. Of the 16 studies that compared simulator trained students with students trained using actual equipment, four reported superior performance for the former, four for the latter, and eight reported no difference. Despite these mixed results, several of the studies indicated that simulator training costs less than training using actual equipment. Only eight of the 22 studies provided cost data. Twelve studies provided Training Cost Ratios (TCRs). Of the 12 TCRs reported, 11 were 1.0 or less. The high TCR of 2.6 was based on initial acquisition of a single trainer. TCRs were computed using life-cycle costs, acquisition costs, and hourly operating costs. Also four CERs were reported ranging from 0.11 to 0.74. The authors were able to conclude that training using simulation was cost-effective.

B. IDENTIFICATION OF DATA REQUIREMENTS AND DATA SOURCES FOR COST-EFFECTIVENESS ANALYSES OF MILITARY TRAINING OPTIONS

In this section we attempt to identify in more detail those data that are needed to accomplish cost-effectiveness analyses of military training options using the TFDM. The identification of data requirements and sources is based on our review of the recent training cost-effectiveness literature and our ongoing experience in conducting the case study to be presented later in this paper. The two types of data needed to feed the TFDM are training cost and training effectiveness data. A complicating factor is that we will need not only past, current, and projected near-term training cost and effectiveness measures, but we will also need longer term estimates of training cost and effectiveness. These projections will be required for the individual trainee engaged in any modified training regimen that might result from training funds investment using new, relatively unproven technology.

1. Current Training Regimen Cost Data Requirements and Sources

This section addresses data requirements and sources for determining the cost and effectiveness of an existing training regimen. It continues by defining the data requirements and sources for potential enhancements to that training regimen or some

totally new training option. Such a dichotomy is necessary because of the speculative nature of much of the data that will be available on any new training regimen.

a. Data Requirements

The major categories of resources required to support various methods of instruction are provided in Table III-1 from Orlansky and String (1979). As previously noted, the authors were evaluating the cost and effectiveness of computer-based instruction for military training using approximately 30 studies conducted since 1968. Unfortunately, they found that direct comparisons of the cost and effectiveness of different methods of instruction were not possible because of incomplete cost data.

Table III-1. Resources Required to Support Various Methods of Instruction (Major Categories Only)

Resource (Type or Function)
Program Development
Program Design
Instructional Materials
Conventional
Individualized Instruction
Programming
First-Unit Production
Computer-Based
Programming
Coding
Program Delivery
Instruction
Instructors
Instructional Support Personnel
Equipment and Services
Laboratory (Including Simulators)
Media Devices
Computer Systems
Communications
Materials (Including Consumables)
Facilities
Program Management and Administration
Student Personnel
Pay and Allowances
Other (Temporary Duty, Permanent Change of Station, etc.)

Source: Orlansky and String, 1979.

Knapp and Orlansky (1983) produced a report identifying, structuring, and defining a list of cost elements that they believed fully described the life-cycle cost (LCC) of any formal program, course, or device for individual training of DoD personnel, regardless of the assumptions imposed by the particular application. This comprehensive cost element structure was developed to satisfy a widely recognized need for consistent, comparable, and credible dimensions for the evaluation of the cost-effectiveness of alternative methods of training. Their cost element structure was developed using a number of authoritative and widely accepted cost guides issued by and for the training and weapons system communities within the DoD. Their list also incorporated many recommendations of reviewers involved in related functions and activities.

The authors believed that the general use of a comprehensive cost element structure such as theirs would offer several advantages for evaluating the costs of institutional training programs, courses, and devices. They listed the following six advantages, of which the second is most important here.

- A comprehensive cost element structure would ensure that all costs incurred during the life cycle (or period of interest) of a training program, course, or device would be taken into account. Gaps in essential data could be identified in this way.
- It would permit reliable and valid comparisons among training options.
- It would provide a level of detail adequate to identify the major cost elements, thus focusing attention on areas for significant cost reduction or for trade-off analyses between high-cost items and training effectiveness.
- It would enable individuals with specific responsibilities that interact with training (e.g., budgeters, manpower planners, procurement specialists) to focus on specific elements of primary interest to them and to evaluate the implications of those resources in a total program context.
- It would assist in identifying significant variables for use in the development of cost-estimating relationships applicable to training programs.
- It would enhance communication and understanding among people concerned with various aspects of weapon system programs on subjects of mutual concern.

Knapp and Orlansky's Cost Element Structure is attached as Appendix A. Of particular interest to this effort is Element C, Operating and Support Costs, including direct and indirect costs. The direct costs include instructional costs, training activity costs, airfield and carrier operations costs (if any), student costs, and other direct costs.

A number of recent studies have tended to support these assumed advantages and the structure itself. For example, Solomon (1986) reported on economic issues in the cost-effectiveness analysis of military skill training. Solomon noted that conventional analyses of training costs hinge on direct costs (personnel, instructors, and materials and supplies), indirect costs (e.g., support personnel, base support), and investment costs (research, development, and equipment). Therefore, when dollar values for the categories listed above are available, the values can be tallied and, given the number of students per training cycle, an average cost per student can be computed. Solomon writes: "When these data are available in either time-series or cross-sectional form, it may be possible to derive 'cost-estimating relationships,' employing some form of multivariate analysis." He cites Samers (1974) as a good example of this form of cost analysis as applied to on-the-job training.

Using the Knapp and Orlansky cost element structure, Fletcher and Orlansky (1989) reviewed recent studies of the cost-effectiveness of military training. Their general findings with respect to cost-effectiveness were reviewed above. However, it is important to note that they found these cost elements were used inconsistently across the 22 analyses considered, even though many of the cost elements were used in these studies. Specifically, the four types of costs reported included initial investment and acquisition costs, student time savings, operating costs, and life-cycle costs. This finding again makes the point that cost-effectiveness figures in the literature for similar training activities may not be comparable because the cost metrics were constructed from different elements.

These three studies show that most of the cost data elements necessary to perform valid and reliable training cost-effectiveness analysis were available 6 years ago. However, based on the recent study by Fletcher and Orlansky (1989), it appears that much of the research community was unaware of the utility of these elements in performing appropriate and meaningful analyses. Since then a number of recent studies have been conducted to refine those cost data elements necessary for the development and maintenance of a cost data element repository at the Training Performance Data Center (TPDC), Orlando, Florida.

Hosek and Peterson (1988) of RAND defined what they referred to as the initial skill training data base files including Military Occupational Specialty (MOS), initial skill training number (ISTN), and time period. The four categories of cost data accessible by these identifiers were personnel costs, equipment costs, course costs, and base operations costs. When their report was produced in November 1988, further studies were under way and the construction of such a database at TPDC was yet to begin.

As a part of the IDA effort, Gibson and Orlansky (1988) suggested that the short-term, best option for a data base to support what they refer to as the cost-production aspect of training system operation would be one in which fairly simple, descriptive data elements were established and organized in a user-oriented manner. They state that these data bases should be capable of accurately tracking and summarizing budget allocations for training costs, student loads, and inventory projections. Additional data bases should be capable of providing descriptive summaries of training facilities and equipment including capabilities, capacities, location, and level of utilization. Gibson and Orlansky conclude that efforts should be made to list, summarize, and simplify the data in periodic and on-demand reports to aid in the development of training policy.

Gibson et al. (1989) attempted to identify the types of data and the data base structure needed to examine a particular training policy question presented as a case study. They concluded that the case study was not fully addressable with the current TPDC data bases. They go on to state that the need for descriptive information pertaining to courses, training equipment, and trained personnel is being addressed by TPDC data base development efforts. Gibson et al. suggested that the data bases should also contain a detailed breakdown of information in the following categories:

- Student costs (time and wage rate)
- Instructor costs
- Course design
- Equipment costs
- Facilities costs
- Cost of technology, if new R&D is required.

Gibson et al. conclude that decision-making requires information concerning both the long run average and the long run marginal cost to train an individual. As of May 1989, data bases to collect information on training system utilization were being conceptualized and prototyped at TPDC.

b. Existing and Planned Sources of Training Cost Data

For the purpose of supporting the requirements of cost-effectiveness analyses, the two most relevant TPDC data bases are the Macro Cost Data Base and the Training Cost Data Base. The existing Macro Cost Data Base is a budget-oriented compilation of training resources. Recent enhancements of this system include update' -iscal Year Development

Plan (FYDP) data in dollars and manpower, a more extensive breakdown of the budget figures, civilian data from within the operations and maintenance (O&M) accounts, cost and workload information from the program element information contained in the Manpower and Training Research Information System (MATRIS), and an automated Standard Reporting System.

According to Gibson et al. (1989) the Macro Cost Data Base may be a model for some of the other data bases. Its report-producing capabilities have expanded progressively and now it routinely produces valuable products for its users. Its strength is in its high-level, resource oriented data presentation. Its most critical weakness for our purposes is that it does not provide a cost-effectiveness justification for possible funding changes. Gibson et al. believe that when this "top-down" data base can be coordinated with several of the planned "bottom-up" data bases, a wide range of training cost-effectiveness policy issues will be directly addressable.

A well-organized and reasonably complete data structure has been developed for the Macro Cost Data Base, and the sources of many of the data elements have been identified. When populated, this structure will allow calculation of the average and marginal cost of individual course graduates and total cost of alternative course throughputs for recruit, initial, and advanced skill training for both individuals and units. Also, recruiting bonuses, special pay, and separation cost data would be collected. This would allow individual replacement costs to be calculated more accurately.

c. Summary

With respect to requirements and sources for current training cost data, it appears that the required categories are well understood and that the specific requirements for the necessary training-cost data bases to make these data accessible are rapidly taking shape. Unfortunately, only limited portions of the required data bases have been implemented and plans for moving forward with this critical need are relatively vague. For example, the recent draft TPDC Information Architecture Overview (TPDC, 1989) does not discuss cost data to the degree and depth of detail that we believe will be necessary.

2. Current Training Regimen Performance Data Requirements and Sources

a. Requirements

Gibson and Orlansky (1986) reviewed and summarized 17 studies concerned with the collection of objective performance data for the purpose of evaluating the effectiveness of maintenance training. They discussed their results in relation to five major aspects of evaluating the effectiveness of training: 1) transfer of training; 2) quality of simulation; 3) effects of training on individual performance; 4) differential effects of alternative methods of training; and 5) the effects of training and experience on unit performance and operational readiness. It is important to note Gibson and Orlansky's conclusion that most of the training effectiveness literature has only marginal usefulness in formulating training policy since it tends to focus on the early effects of training. Consequently, increased data collection efforts should be directed toward assessing the long-term effects of training and experience on the quality of individual performance, unit effectiveness, and, ultimately, on combat readiness.

Most of the 17 studies and measures reviewed by Gibson and Orlansky (1986) were designed to assess the effects of formal training and experience on maintenance performance. Because of the costs in time and effort needed to produce skilled technicians, it was not only reasonable but essential to consider whether the training methods and devices had any real effect on maintenance performance. Only eight of the studies presented used maintenance performance measures to determine whether training made any measurable difference in productivity. Three of the training effectiveness measurement studies compared the performance of maintenance technicians who were trained on maintenance training simulators to the performance of those trained on the actual equipment.

Solomon (1986) observed that there are significant problems in the representation and measurement of training effectiveness. One approach is to follow current practice and use a level of knowledge and skill represented by a score resulting from one or more tests administered during the course. Solomon concluded that information on effectiveness is limited generally to student performance at school despite the fact that the more important and revealing measurement of training effectiveness is performance of the individual on the job. Unfortunately, as Solomon noted, it has rarely been possible to relate empirically the level of achievement in school to job performance (productivity). Hence, he concluded that it has not been possible to relate alternative training methods in schools to job performance.

According to Gibson and Orlansky (1988), a data base that supports policy-making efforts on the basis of performance effectiveness data should provide information on the skill levels achieved through initial skill training, on-the-job training, and post-initial skills individual, team, and unit training. Gibson and Orlansky further observe that the performance effectiveness data requirements can be divided into two categories:

1. Data that relate the performance levels achieved through formal training programs to the skill levels and mixes required by the operating forces, and
2. Data that relate post-initial skills training activities (such as flying hours) to maintaining or improving skill levels while performing in the operational environment.

Test scores and course grades satisfy part of the first requirement and they provide a basis for judging the effects of changes to the training program provided that the same tests are used to measure the training results. In our case, the test data would be much more valuable if they could be directly equated to definable levels of apprentice or journeyman performance in the field. If equivalencies could be established, it would become possible to definitively link the costs of training to specific levels of competence, which are what we need for our analysis.

In their review of 22 recent studies on the cost-effectiveness of military training, Fletcher and Orlansky (1989) found that the types of cost and effectiveness data collected in these studies did not permit examination of trade-offs between cost and effectiveness. The range of effectiveness measures considered by each individual study was narrow. None of the studies considered all five of the categories listed by Chatelier et al. (1985). Moreover, only seven studies considered attitudes of either students or instructors; only three considered student attrition; and none considered on-the-job performance. On the other hand, all of the studies considered end-of-course effectiveness, and all but two of the studies considered transfer of training from simulators to real equipment. Unfortunately, student time savings through use of actual equipment was treated as both a cost and an effectiveness measure. Eight of the 22 studies measured time to complete a task using actual equipment and four other studies measured success in maintaining or operating actual equipment as an indicator of effectiveness.

b. Available Sources of Training Effectiveness Data

Do the necessary data and/or data bases exist to facilitate a systematic attempt at the measurement of training effectiveness (i.e., individual productivity/proficiency change that

results from training)? String and Orlansky (1979) concluded that then-current large-scale maintenance information systems did not provide the required information about individual performance needed to relate individual training to productivity. Gibson and Orlansky (1988) and Gibson et al. (1989) were still concluding that little had been done to assemble the necessary data bases to address the training effectiveness measurement problem. Gibson et al. did find that the TPDC data bases contain some performance data on personnel characteristics which may predict the quality of achievement in school or in the field and some data on the effectiveness of the various training systems in satisfying approved training requirements or on the number of people completing established training syllabi. However, they found little or no performance data addressing the effects of training courses or techniques on the quality of individual or group achievement either at the end of the course or under operational conditions. It is these latter data that are most critical for our proposed analysis. The authors go on to suggest short-, intermediate-, and long-term strategies for developing the necessary performance measures and supporting data bases.

Gibson and Orlansky (1988) believe that the most important long-term strategy must be to develop performance measures that relate training achievement levels to operational apprentice or journeyman skill levels. Only if this can be achieved will it be possible to develop meaningful cost-effectiveness trade-offs for training. Gibson and Orlansky suggest that the commands that receive the new trainees could be tasked to provide feedback on training effectiveness with these students by routinely producing Net Productivity Ratings of first-term personnel assigned to the command. These ratings would partially fulfill the above objective. However, they require a minimum delay of 18 months to 2 years to assess the effects of training programs on the quality of performance, and they confound student and supervisor productivity information, partially masking the specific effects of training on student performance.

In agreement with the present authors, Gibson and Orlansky (1988) believe that a scale relating training achievement to operational skill levels would provide immediate feedback. It could also be used to determine the costs of training to a specified skill level. This would make many training decisions more directly analogous to hardware cost-effectiveness trade-offs in which the costs of training to a specified criterion could be weighed against the anticipated operational benefits. Finally, they note that the long-term strategy should also encourage the development and validation of highly aggregated measures of the effects of collective training (e.g., training as a force multiplier).

c. Summary

In summary, with respect to the data requirements and data sources necessary to measure current training regimen effectiveness, despite a growing appreciation of the requirements, very little has been done during the past decade to create the necessary on-line data bases to support them. In particular, the current draft TPDC Information Architecture Overview (TPDC, 1989) contains very little of the necessary data.

3. Cost Data Requirements and Sources for Modified, Enhanced, or New Training Regimens

The previous two subsections addressed the measurement of costs and training effectivenesses of current training regimens, i.e., those for which some historical data should exist. To make funding decisions about contemplated, new training regimens requires a priori estimates of their cost and effectiveness. This subsection and the next address the special issues involved in such a priori, comparative analyses.

a. Requirements

The key to measuring or estimating the cost of modified training regimens is to accurately determine the cost of the new technology to be inserted in addition to or in place of the current technology and to estimate the effects of such insertion on all other training costs. In so doing, we face essentially the same difficulties we faced when attempting to measure the cost of any current training regimen, compounded by the uncertainties of the modified training regimen's effect on time to train. Up to now, most cost savings are due to reductions in time needed to train personnel to a specified level of proficiency. Any cost analysis we perform for a modified training regimen must be focused on the particular new/existing technology in which we are planning to invest, for example, CBI/IVD. Typically, we have been required to look for data in the research literature.

In the previously referenced report on recent studies of the cost-effectiveness of military training in TTCP countries, Fletcher and Orlansky (1989) found that even researchers attempting to measure the relative cost-effectiveness of new approaches to training fail to use an adequate set of cost data. Only 4 of 10 possible cost categories (Table III-2) were considered in their set of studies. They concluded that the cost data were incomplete (and potentially misleading). Only 8 of the 22 studies purporting to measure cost-effectiveness provided any cost data at all!

Table III-2. Effectiveness and Cost Data Provided by 22 Empirical TTCP Studies

Types of Data	Number of Studies
Effectiveness Measures	
End of Course	22
Transfer	20On-the-Job
	0
Student Attrition	3
Instructor Attitudes	7
Student Attitudes	7
Cost Data	
Research and Development	0
Initial Investment	
Program Development	0
Acquisition	3
Operating and Support	
Student Pay and Allowance	0
Instructor Pay and Allowance	0
Maintenance and Repair	0
Program Modification	0
Student Time Savings	8
Operating	4
Life-Cycle Costs	
(includes all of the above)	2

Source: Fletcher and Orlansky, 1989.

b. Sources

There are few sources from which to derive the cost data required for predicting the cost-effectiveness of training regimens based on new technologies. An exception is the planned TPDC CBI/IVD training technology data base (TTDB). Cost models and cost-estimating procedures will be required to fulfill our needs. We can also extrapolate from historical data for similar technologies.

c. Summary

In summary, with respect to the modified training-cost data requirements and sources, we face a more difficult situation than we did for existing training regimens. The

categories of cost data required will remain basically unchanged except for a greater emphasis on up-front research, development, and acquisition costs.

4. Performance Data Requirements and Sources for Modified Training Regimens

Cost data requirements and sources for modified training regimens are intimately related to performance data requirements and sources. This is because any cost savings from the new technology is most likely to come from the increased efficiency of the new/modified training regimen in providing the necessary training. Efficiency in providing training is directly related to the performance proficiency that results from training. The more rapidly the latter rise to criterion for the trainee, the more efficient we say the subject training regimen is. By necessity, our primary focus here must be on techniques and methods for measuring the differential training effectiveness of alternative training regimens as indicated in the literature reviewed below.

a. Data Requirements

We now present the findings from a number of studies that focus on training performance data requirements, particularly with respect to measuring the effects of modified, enhanced, or entirely new training regimens, all typically making use of relatively new technologies. The emphasis is on the measurement of the differential effects of alternative training options, that is, comparative studies.

Orlansky and String (1979) suggest measurement of performance of graduates on jobs in the field as a sound approach to postgraduate monitoring of students after their assignment to duty stations. Such data are not now collected systematically. In their review of 30 studies of CAI/CMI, the authors found the following measures of effectiveness used for comparative purposes:

1. Student achievement on tests administered during and/or at the end of course
2. The length of time required for students to complete a course
3. Academic attrition rates
4. Student and instructor attitudes.

One measure of the differential effectiveness of training regimens that might be more seriously considered relates to observed differences in training time periods for different training techniques and methodologies, for example, the use of simulators versus actual equipment. In a number of cases, it has been possible to estimate these differences

(see Orlansky and String, 1979, 1981). The limitation has been the difficulty in obtaining information on how these measures relate to on-the-job performance. Nevertheless, observed differences in the duration of required training periods represent, or at least suggest, differences in cost.

Gibson and Orlansky (1986) also addressed the measurement of the differential effects of training methods. They focused on the comparative differences between simulators and actual equipment for training, which has been a major source of concern and controversy in the maintenance training community. From a total of 17 studies, they examined closely three concerning differential training effectiveness measurement. The measures used in these studies included troubleshooting interview, behaviorally anchored rating scales, and speed of diagnosing malfunctions. Gibson and Orlansky note the hazards of giving absolute interpretations to the ordinal data produced by the first two measures. Gibson and Orlansky also reviewed a number of job performance measures that could be used to evaluate relative maintenance training effectiveness. Among those identified were speed of completing maintenance work and net productivity ratings. Both metrics were sensitive to differences in training techniques [see Johnson, et al. (1983), McConnell and Johnson (1984), and Quester and Marcus (1985)].

Solomon (1986) notes that an alternative to using direct on-the-job measurements of productivity to measure the relative effectiveness of training methods is to use relative standards of achievement. Unfortunately, this is not a viable measure for technology that has not yet been inserted. However, if we believe that we have enough existing, comparable cases of insertion of the same technology or a highly representative one, then we might wish to consider the use of relative standards of achievement to measure the differential proficiency of alternative training regimens.

Solomon reviewed the study by Quester and Marcus (1985), which used survey data and provides a good example of the application of a relative standard. By using data from the Enlisted Utilization Survey and Navy administration records, they were able to compare the cost-effectiveness of formal school instruction and on-the-job training. The measure of effectiveness was net productivity of the individual at different times at the duty station. ("Net" refers to subtracting the loss in production of more experienced supervisory personnel required to train these individuals.) This assessment by the supervisors was made relative to the average specialist with 4 years of experience; it is an example of a relative standard. The results of the study suggested that school training is more effective and also more cost-effective than on-the-job training.

Hosek and Peterson (1988) of RAND note the importance of longitudinal data as a key requisite for a training effectiveness data base. They assert that longitudinal data will enable comparisons of cohorts, evaluation of policy changes, studies of changes in skill requirements over time, and, most importantly for our purposes, comparison of different methods used over time in the same course. Such data are not currently being maintained, although some of it could be reconstructed from existing data bases.

The above cited review by Fletcher and Orlansky (1989) concerning recent studies on the cost-effectiveness of military training in TTCP countries focused primarily on studies that compared the effectiveness and cost of relatively inexpensive part-task simulators versus full-task, highly realistic simulators. As noted in Section 2 (above), the authors found the range of measures considered by these studies to include:

1. Student and instructor attitudes
2. Student attrition
3. On-the-job performance
4. End-of-course effectiveness
5. Transfer of training to real equipment
6. Time savings in use of actual equipment
7. Success in maintaining or operating actual equipment.

Gibson et al. (1989) discussed the key issue of qualitatively different training integral to the new technology. They note that new training technology is often implemented not only because it allows the same things to be done for less money, but also because it has capabilities or allows training strategies that are qualitatively different from those previously available. A possible example of this might be that interactive videodisc (IVD)-delivered training could allow students to perform actions that would be harmful to themselves and/or the equipment on which they would otherwise be training. While these qualitatively different capabilities may be the key reasons for implementing such technology, they make analyzing the cost-effectiveness of the technology insertion more difficult. Performance measurement will ultimately be necessary to quantify this improvement in order to complete our analysis.

b. Data Sources

As with most of the other categories of data identified previously, few if any of the data are being routinely collected and stored that are necessary for measurement of the relative effectiveness of different training regimens.

c. Summary

A number of authors have begun to identify the data necessary for comparing the effectiveness of different training regimens. However, few of these data are now being systematically maintained in data bases or even appear to be used systematically in published research studies.

C. A TRAINING FUNDS DECISION METHODOLOGY (TFDM)

In this subsection we make explicit the Training Funds Decision Methodology (TFDM) which in Chapter IV we will apply to two versions of a case study involving electronics maintenance training. This methodology draws upon a history of approaches to cost-effectiveness analysis for military training. It also takes into account training cost and effectiveness data requirements and the current realities of data availability for cost-effectiveness analysis of military training options. In the subsections that follow, we will develop the five-step TFDM procedure. We will then proceed with separate, more detailed discussions of each step.

The basic five-step procedure for the TFDM appears in Figure III-1 and is briefly described as follows:

1. Frame the Question--based on the general concerns being raised in the specific training-funds decision context, match the current analysis situation with one template or schema chosen from a predefined taxonomy of possible analysis situations.
2. Make the Options Explicit--based on specific questions and concerns, including training or performance objectives, develop alternative training plans; this may require some up-front analysis to ensure adherence to cost and performance constraints.
3. Determine Costs of Options--determine the explicit anticipated costs of each training option in all relevant cost categories; this may require the use of a cost model to provide a fair comparison of the costs of the various alternatives.

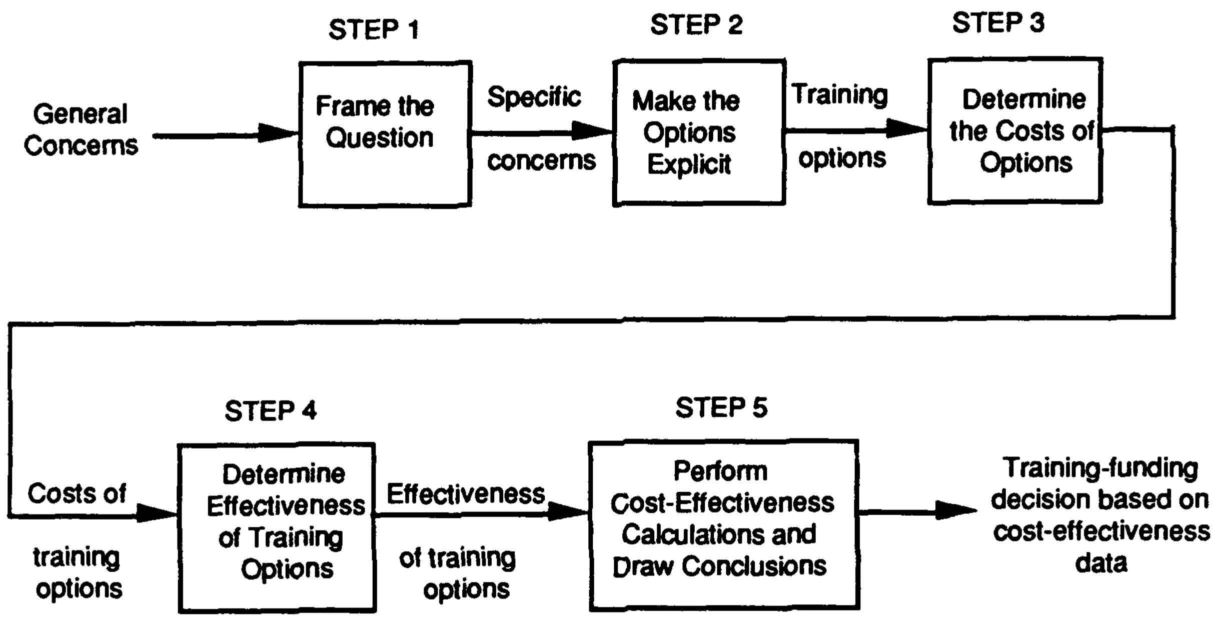


Figure III-1. The Training-Funds Decision Methodology

4. Determine the Training Effectiveness of Each Option--predict the gains in job performance productivity/proficiency that would result from each training option; in some cases, the research literature may be our best and only source for such data.

5. Perform Cost-Effectiveness Calculations and Draw Conclusions--determine the productivity/proficiency gains to be expected per unit cost for each training option and draw final conclusions regarding the most desirable option, taking appropriate constraints (e.g., budgetary, time to train) into account.

We will now proceed with a discussion of each step in the TFDM.

1. Step 1: Frame the Question

The training funds decision-maker will bring with him to any decision context or policy analysis situation general concerns regarding the issue(s) in question. At this stage in the TFDM, the first goal will be to define and limit the question. One way of accomplishing this is to search within a taxonomy of possible decision contexts, for an a priori decision-making/policy analysis template (frame or schema) to match the current situation. Once this match has taken place, the various components of the selected analysis strategy can be made explicit, that is, the frame can be applied. For example, there might be a generic analysis template for decisions concerning the funding of increased R&D and

for applications of a relatively new method of instruction (e.g., the use of CBI/IVD technology).

Gibson et al. (1988) suggested one possible taxonomy of training policy issues having seven components. The components and their descriptions are as follows:

- Training Type. Is the training designed to develop individual skills or collective skills? Typically, analysis of individual training will require substantially different kinds of data than analysis of collective training.
- Performance Standards. Does the policy issue involve a change in the performance levels to be achieved through training? If it does, data on performance or effectiveness will certainly be required for analysis of the issue. (Analysis of many policy issues that do not involve changing performance standards also requires effectiveness data.)
- Training Time or Frequency. Does the issue involve how long the training should continue or how frequently it should be repeated? Measurement of the costs of the alternatives involved in issues of this kind may be relatively simple, since they involve just doing more of something that is already being done. However, effectiveness information is necessary to analyze such issues.
- Training Volume. Does the issue concern how many people or units should be trained per time period? Issues that involve only training volume should be particularly easy to analyze, since the effectiveness data needed to study them are likely to be easier to get than data on the performance implications of new or intensified training.
- Training Technology. Does the issue revolve around a possible choice of innovative training technologies? Such issues may require measurement of research and development costs and measurement of effectiveness. They seem certain to involve some procurement costs for instructional equipment.
- Course Design. Does the policy issue encompass a choice among alternative course designs? Even if new technologies are not involved, data on R&D costs are likely to be necessary to analyze such issues.
- Location. Is it contemplated that some training will take place at a new location? If so, information on construction costs will probably be required for analysis (as well as information on the costs of transporting individuals and units).

As an example of the approach, the previously cited Canadian TMM implicitly assumed a partial taxonomy of decision contexts involving at a minimum 11 components. See Figure II-5, above.

It is not our purpose to develop the necessary, all-inclusive taxonomy of training policy issues and/or decision contexts. The point to be made is that such a taxonomy will allow us better to anticipate and plan for the complexities of any one analysis, particularly with respect to identifying the types and sources of the necessary training cost and effectiveness data. Appendix B is a summary of those steps to be taken and associated questions to be asked in making training-policy decisions, and Appendix C gives a list of training-policy decision information items for each of the five major steps in the TFDM.

2. Step 2: Make the Options Explicit

Once the policy issue or training funds decision has been framed, we move to making the options explicit. Doing so will typically require that detailed alternative training plans be developed. These plans are all comparable in that they will be derived to meet performance objectives which are themselves derived from an analysis of the requirements of the job to be trained and the tasks for which the training is to be conducted. The plans may vary with respect to such factors as:

1. The method of delivery (e.g., self-paced versus group)
2. The duration of training
3. Location of training (e.g., school versus on-the-job)
4. The type of equipment used (e.g., simulation versus actual equipment).

Training options/alternatives must be clearly delineated so that an explicit context is provided for the determination of both cost and effectiveness. It may be necessary to start with a baseline training option (usually the current mode), even though the policies/options under consideration are all deviations from that baseline. The explicit time-phasing of the introduction of alternatives into the training process will be critical in order to subsequently determine the life-cycle costs. (See Appendices B and C for a summary of the activities involved in this step and the associated information items.)

3. Step 3: Determine the Costs of Options

The average cost to provide each training option for an individual trainee must be determined. Let us refer to this quantity as the training cost for option i, TCi. There are obviously several different MOSs at several different ranks which could be considered for training in a given situation. Let us take one particular set of skills taught to a specific rank or set of ranks, for example, electronic equipment maintenance and repair. We need to determine the average cost to implement each training option for these skills/ranks for one

soldier. In order to do so, we must first identify the course or sequence of courses in which these ranks will acquire the particular skills and, through analysis and/or modeling, attempt to answer the following question: "What is the cost to train one individual (the cost per graduate) using the training option under consideration, assuming simple formal training costs and taking student attrition into account?"

Ideally, this question would be answered by accessing the data base in which the necessary data are stored to calculate the long run average cost to train an individual through the particular training option. These data should be broken down into at least the following categories:

1. Student costs (time to train and pay and allowance rate)
2. Travel, food, and lodging costs
3. Instructor costs
4. Equipment and facilities costs
5. Other related costs, as previously discussed.

Basically, we are asking the question, "How much does it cost to get one person through the particular part of the training pipeline on which we are focusing?" It may be necessary to aggregate across several courses in a sequence and to take course attrition into account. Nevertheless, we are focusing on the simple formal training costs and, if necessary, the R&D investments required to bring training technology to the level at which it will be applied in these courses. We will return later, in our case study, to an explicit consideration of the exact format of cost information and the sources for the cost data that we will need.

For some options, it may be necessary to determine the cost per student for training that involves some new technology. In some instances it may be the case that we will be paying no new R&D costs for this technology, that is, we may be applying an existing technology, but not paying to develop new technology. In such situations, we will be purchasing off-the-shelf hardware and software and paying for the development of courseware. Nonstandard/specialized hardware or software may be necessary for our application, and some accounting should be made for this possibility.

If the above situation holds true, we will need to calculate how the particular technology that we will bring to bear in this training option will affect the average cost to run an individual through the relevant portion of the training pipeline. Since the necessary

data are not likely to exist, we may need to estimate them on the basis of historical data that reflect the costs in similar training domains, where more or new technology has been brought to bear. We know, for example, that equipment costs (including hardware, software, and courseware) will go up, but these will be spread across many individuals and amortized over time. It is possible that time to train and associated costs will go down if the new training regimen is more effective and training occurs to a specific criterion level of performance. It is also possible that the time to train will be deliberately held constant and the result of the new or added technology will be seen in a greater proficiency increment. It may be that fewer instructors will be necessary, but possibly more facilities (floor space) for training equipment may be required. All of the potential trade-offs must be identified and estimates of the cost per student completing the training option must be calculated.

It is possible that the training cost for new high-technology training options will not be less than the cost for old, lower technology options, despite any savings in time to train. There is a certain investment in the existing infrastructure that makes it very slow to change. For example, it is likely that the duration of a sequence of courses would be modified only after a great deal of data is gathered. We may therefore find ourselves asking whether an increment in proficiency associated with a training option, which includes new technology, is worth the increase in cost that we will incur.

The above arguments notwithstanding, it is possible that, given the current emphasis on training to criteria, the cost per person to train might decrease under any training option involving new technologies. Additionally, there are certain intangibles that come along with new technologies, IVD for example, that provide difficult-to-measure increases in readiness. Examples of such increases include a greater ability to respond to real-world situations due to greater realism in the training. The two versions of the case study to be presented below will provide more insight into these issues. Table III-3 summarizes the major issues addressed above with respect to the computation of TCi. (See Appendices B and C for a summary of the activities involved in this step and the associated information items.)

Table III-3. Determine the Training Costs for Each Option (TCi)

TCi = The cost to train one individual of a specified MOS through a specified sequence of courses (the cost per graduate, taking attrition into account) using a specified training regimen and suite of associated equipment

Elements of TCi (the long run average cost to train an individual through a particular sequence of courses) include the following:

1) Student costs (time to train multiplied by pay and allowance rate)
2) Travel, food, and lodging
3) Instructor costs
4) Equipment costs
5) Facilities costs
6) Other related costs
7) New hardware, software, and courseware, if appropriate.

NOTES:

1) This is the simple formal training cost.
2) The course sequence will address the acquisition of a specific skill set (specialty), usually for a single rank or a narrow band of ranks.
3) We may be aggregating across several courses in a sequence.
4) Course attrition must be taken into account.
5) Do not consider previous R&D investments to develop the current training regimen or the new training technology (we are considering only off-the-shelf state-of-the-art).
6) Assume no new "costs of technology" (i.e., no new R&D; we are applying the state-of-the art, not advancing it).
7) These costs may be divided among several course sequences in which the same new hardware, software, and courseware are put to use.
8) Nonstandard/specialized hardware and/or software may be necessary for a particular course sequence.
9) Time to train and associated costs (e.g., number of instructors) may decrease, leading to an overall cost decrement.
10) All new hardware, software, and courseware costs must be suitably amortized over time.

4. Step 4: Determine the Training Effectiveness of Each Option

We now face the difficult question of training effectiveness, that is, the incremental gain in proficiency provided by each training option. Let us refer to this quantity as the training effectiveness for option i, TEi. Whether the training options are teaching new skills for the first time or providing for the augmentation or remediation of old skills, it is important to measure the trainee's ability to perform the requisite tasks both prior to and subsequent to the training options under analysis. In some cases, the a priori testing may be waived because the student may simply have no ability to perform the particular specialized tasks before the subject training.

What we seek here are performance-oriented metrics that can be applied pre- and post-training and that can be related to proficiency in performing the skills in question. These measures must assure that the data they produce are at an interval-scale level of measurement, or can be converted to such a scale, so that differences can be included in a cost-effectiveness ratio. It should be noted that the practice of fixing either cost or effectiveness in training cost-effectiveness analyses typically seen in the literature is both arbitrary and unnecessary if one assumes that both cost and effectiveness can be measured on at least an interval scale, as we have required in our methodology. In addition, the measures must depend on data that already exist or can be derived and must assure that the data be available pre- and post-training. In fact, the best data we might have are fitness reports before and after training. In the final analysis, however, we must be capable of measuring skills relevant to performing the tasks in question or possess the ability to measure performance on the specific tasks in question for which such skills will be put to use.

Applying the pre- and post-training performance metrics in the context of new technology may be difficult since, unfortunately, it is not always possible to give such technology a preliminary trial. The cost of developing the necessary courseware and applying it on a limited basis can approach 50 percent or more of what it would cost to apply it to all the students in a training sequence. If pilot tests are not appropriate, from where do we derive these data? First, we turn to the data on training effectiveness that we can deduce from similar, previous applications of training methodologies and technologies. We ought to find data on proficiency increments resulting from such previous applications. If these do not exist, we could look at data for other related technology enhancements in the past, for example, the introduction of CBI in the 1970s and early 1980s.

A good source of the necessary data is the research literature, but the data will have to be interpreted and/or extrapolated. For example, there is the possibility that a qualitatively different training effect is inherent in the new technology applied in one training option and not provided by the older technology in another option. Similarly, the existing literature suggests that it takes 30 percent less time to train to criterion using IVD technology versus existing training methods (Fletcher, 1989, 1990). How such statistics translate into increased proficiency is not clear, but an effort at such translation is necessary for the success of our methodology.

We must then convert the estimates of the training effectiveness of each option to common interval scale measures of student average proficiency at performing the requisite tasks/duties/skills. We will need measures of student average proficiency gains at performing the requisite tasks for each option, taking speed and accuracy into account. Specifically, we will require data on average training effect size due to the alternative training regimens (from the research literature if necessary) for the appropriate student population and performance area. The following measures could all prove useful in computing the final interval scaled quantity necessary for our analysis:

1. Knowledge and performance training outcomes (paper and performance tests)
2. Retention of trained skills and learned knowledge
3. Post-training fitness reports (or estimates) for each training option
4. Time on task during training (secondary measure)
5. Time to complete instruction (secondary measure)
6. Time to complete performance/knowledge tests (secondary measure).

Once all of the above data are gathered, we must aggregate them using a function we will develop for converting these measures of student proficiency gains to an interval scale. The form of this aggregating function depends on the relationship between performance measures and long-term military proficiency. However, we may only need to weight appropriately (in a subjective manner) the various measures in order to combine them. For this reason the aggregation may be linear or nonlinear and may require us to view the individual proficiency measures as independent or related. This could involve some nonlinear transformation of one or more of the scales so that ratios of differences on any one (and therefore a weighted average of all measures) will prove meaningful. For example, a 10-point improvement on post-training paper or performance tests may not be worth half as much as a 20-point improvement on the same tests. It may be worth, for

example, two-thirds as much in terms of its implications for long-term military proficiency or ability. In combining measures into our final unidimensional interval scale measure, it will be important to take their nonindependence into account.

A final point to be made with respect to determining the proper measures to use in our analysis is that, ideally, our measure of the effectiveness of training would relate more to the military value of training (for example, its contribution to readiness) than to the improvement in individual performance. For now, however, we will not attempt to address or even to raise this difficult issue. We will simply comment that measurement of contributions of training to readiness and, ultimately, success in battle should be the goal for which we strive.

It should be noted that some of the difficulty in measuring the differential training effectiveness of training options might be obviated by the emphasis on training to criterion. That is, we may be able to assume that, under any option involving new or enhanced training technology, no increase in proficiency will occur since the same standard set of criteria are used to determine when the degree of training has been sufficient. This assumption may greatly simplify our methodological approach. Table III-4 summarizes the key considerations for computing the quantity TEi. (See Appendices B and C for a summary of the activities and information items required for this step.)

5. Step 5: Perform Cost-Effectiveness Analysis and Draw Conclusions

With the data generated by implementation of the first four steps of the TFDM, it is possible to compute and compare the ratios of training effectiveness (the increment in student proficiency) to the cost per student for each training option. If one option provides a higher ratio of incremental productivity per dollar, then it is the option of choice, assuming it meets budget constraints and that there are no significant nonmonetary arguments to the contrary. We will be interested in the percentage difference in cost-effectiveness between options.

Table III-4. Determine the Training Effectiveness of Each Option (TEI)

Training Effectiveness i =	The increase in a single student's proficiency/ability at performing the tasks/duties/skills for which a particular training option is designed to provide training
Proficiency =	An interval scale measure of a student's ability to perform a designated set of tasks which takes into account accuracy and speed (i.e., an interval scale measure of accomplishment per unit time)
Sources of Data:	1) Similar existing training applications for options of the new, modified, or expanded involving new training methodology/technology 2) Past training applications of similar training technologies 3) The research literature 4) Common sense and guesswork.

NOTES:

1) In general, a single course sequence will train one rank or a narrow band of ranks to perform the duties of a single MOS or several associated MOSs.
2) Ratios of differences in proficiency (i.e., training effectivenesses) are appropriate for use in an effectiveness/cost analysis.
3) The value of the qualitatively different training provided through any new training technology must be taken into account.
4) Increased speed in task performance as a result of training is a critical consideration for training options involving few technologies.
5) Even if training is continued only until a pre-defined set of performance criteria are met, there may well be an increase in productivity resulting from the new training regimen/procedures.

To illustrate the above, let us assume that we have taken a multimethod approach to measuring proficiency and have developed a scale (some linear combination of nonlinear functions of other measures taken on other scales) that measures an individual's ability to perform his necessary tasks and duties on an absolute interval scale from 0 to 100. Prior to the current training sequence, the individual may perform at a proficiency level of 50 (which we will assume to be unacceptable) on the requisite skills, tasks, or duties. After training, the individual's score may be, for example, 89, which we consider quite good relative to our highest score of 100. We may also have determined that the average cost to train an individual through this segment of the training pipeline is $15,000. We therefore have a ratio of 39 proficiency units to $15,000, or 2.6 units of individual proficiency per $1,000.

Given the cost and proficiency measures that have been described above, we can calculate the necessary ratios of training effectiveness divided by cost and perform comparisons of effectiveness/cost ratios and other key factors. We will be interested in the percentage difference in cost-effectiveness between options. We will also be interested in comparing the number of trainees through the pipeline per unit time and forcewide increases in proficiency. Finally, we will want to compare the total costs of training for all trainees who can be trained in a fixed period of time.

6. Summary

We have provided a general overview of our five-step TFDM procedure. Our goal is that it serve as a general guide for the case study we will now develop. The case study involves the application of CBI/IVD training techniques and equipment to electronics maintenance training. This application should assist us by providing the additional insights necessary to "add meat to the bones" of the general TFDM outlined above. It is also possible that the results of this "pilot test" of the TFDM will prove valuable in their own right in the context of today's resource allocation decisions.

IV. APPLYING THE TRAINING FUNDS DECISION METHODOLOGY TO A CBI/IVD RESOURCE ALLOCATION DECISION: A SAMPLE CASE STUDY

This section presents an illustrative case study demonstrating the application of the Training Funds Decision Methodology (TFDM). In it we address the following question: "Should support for computer-based instruction/interactive videodisc technology (CBI/IVD) for electronics maintenance training be increased by a specified amount?" Such an inquiry assumes that the general, possible, and realistic order of magnitude of such an increase is known in advance. This increase will be some quantity large enough to have a foreseen positive impact on the effectiveness of electronics maintenance training, but small enough to comply with realistic budget constraints.

A significant amount of up-front analysis would have to be performed to determine the proper magnitude of this increase and to assure that it represents an increase large enough to truly have a positive impact on electronics maintenance training. This does not imply the need for a complete analysis of hardware, software, and courseware that could be bought with the specified increase, only that the increase be seen as large enough to merit the effort of a more thorough analysis. Indeed, an informal cost-benefit analysis should ideally be undertaken a priori to identify the best candidate technologies for consideration to receive funding increases and to determine the appropriate orders of magnitude for such contemplated increases.

We will now proceed with two versions of a CBI/IVD case study for electronics maintenance training. The fundamental difference between the two is that, in the first, both acquired proficiency and cost of training change; in the second, training time alone changes. The same proficiency level is attained in both the original (i.e., current) and the modified (i.e., to include more CBI/IVD technology) training regimens. As previously noted, however, there are likely to be certain difficulties in measuring changes in the proficiency with which a soldier will perform his electronics maintenance specialty. This is due especially to the fact that increases in training funds generally tend to go toward systems that provide more realistic environments in which to train. Such is the case with

CBI/IVD, which leads to greater performance proficiency in the anticipated actual wartime setting.

A. VERSION 1 OF THE CBI/IVD ELECTRONICS MAINTENANCE TRAINING CASE STUDY

Let us assume that a $125,000 training augmentation is being considered which will provide for the purchase of new CBI/IVD hardware, software, and courseware to train a specific MOS involving the repair and maintenance of electronics equipment. The question to be addressed is, "How cost-effective would such an investment in new/enhanced training technology be, compared with the alternative existing training regimen?" To determine whether this is a wise investment, we will proceed through the five steps of the TFDM as described in the previous chapter.

1. Step 1: Frame the Question

Here we match the CBI/IVD analysis situation with a similar analysis template chosen from a predefined taxonomy of possible choices. In terms of the seven components in the Gibson et al. (1988) taxonomy of training policy issues, our question can be analyzed as follows:

1. The question addresses individual training.
2. Performance will be allowed to vary (in the first version of the analysis).
3. Training time may vary.
4. Training volume may vary.
5. An innovative training technology is concerned.
6. Course design may change.
7. Location is not likely to change and new facilities are unlikely to be necessary.

In terms of the components of the Canadian (1987) taxonomy, we observe the following characteristics represented in our question:

1. This is a relatively new method of instruction.
2. We are addressing one new training resource, not a mix.
3. We will look at individual performance.
4. Our focus will be on technology but involve individual courses and a particular specialty area.

5. We are not trying to optimize a mix of training resources.
6. We are not looking at ease of training for a new system.
7. We will be implementing and evaluating (to make our choice) a new method, but not developing it.
8. Ideally, we will be focusing on the tasks to be trained and associated performance objectives.
9. We are not evaluating a training organization or infrastructure; however, CBI/IVD may require some change in these.
10. We will have to analyze training research data because of a lack of applications data on CBI/IVD.
11. We will not be making training-related system design decisions.

In terms of Table II-2 relating decision contexts to cost elements and effectiveness levels, this question for analysis best matches Column 1, "Evaluation of new method of instruction for a course." Therefore, initial investment and direct operating costs will be more important than R&D, Support, Training Infrastructure, and Training Resource costs. Attainment of course performance objectives will be the best measure of training effectiveness levels available to us.

2. Step 2: Make the Options Explicit

We have already established that an investment of $125,000 is being contemplated for the purchase or development of new hardware, software, and courseware to be used in a typical four-course sequence to train a specific MOS involving the repair and maintenance of electronics equipment. We estimate that this will pay for 10 video disc systems costing $10,000 each, as well as the courseware and software development costs of $25,000. Let us assume that there is already some modest CBI, as well as actual electronics equipment workstations, involved in the course sequence as currently taught. The new CBI/IVD-based training would replace the existing CBI-based instruction, using a small portion of the existing computer hardware and some of the software. The old courseware would become obsolete. Let us also assume that we are looking at the next 5 years as the useful lifetime of the new training technology. Finally, let us assume that in any one of the 5 years, an average of 120 trainees will progress through the sequence with the new equipment, as we discussed above, starting with 100 in Year 1 and linearly increasing to 140 in the fifth and final year.

3. Step 3: Determine the Costs of Options

Remember that we are seeking to determine the cost to train one individual using the four-course sequence of electronics maintenance courses for this MOS, first making no changes and next introducing the new technology. The courses will be substantially modified as a result of the subject CBI/IVD technology insertion. It should be noted that the contemplated investment could actually affect more than one MOS and several sequences of courses. If so, we would need to perform this analysis for each and aggregate all costs and proficiency gains appropriately. However, for the purpose of this case study, we will stay within the narrower context.

Once we have determined the course(s) or course sequence(s) affected, we must determine the average long run cost to train an individual using them. Since there are four such courses, we will be aggregating student costs, travel, food and lodging costs, instructor costs, equipment and facilities costs, and other related costs as identified by Orlansky and String (1979). Let us assume that the particular four-course sequence affected involves courses taught in two separate 1- month visits to a training school with each visit separated by 6 months and that the average cost for this training is $25,000 per student, taking all costs into account. The old equipment has allowed us to train 100 students per year, but we expect to increase the number of trainees to 110 in the second year of the new equipment, 120 in the third, etc. For our example, assume that the current training regimen costs break out as follows: $5,000 in student costs; $5,000 in travel, food, and lodging costs; $5,000 in instructor costs; $5,000 in equipment and facilities costs; and $5,000 in other related costs. A data base designed to handle data such as these is under development at TPDC. It should be noted that the assumed costs above are somewhat arbitrary and were chosen to make the case study easy to understand. They are representative of historical case data surveyed by the authors, but not meant to replicate any one particular case study. Our primary purpose in presenting these numbers is to demonstrate the operations in the TFDM.

We must now determine the sum of the costs per student for new hardware, software, and courseware, as well as all related costs as above identified. It should be noted that the related costs are likely to decrease as a result of the technology investment. For example, student time and instructor time are likely to decrease, the former by approximately 30 percent and the latter by 40 percent (Fletcher, 1990). The first critical step is to determine exactly what CBI/IVD hardware, software, and courseware, together with any necessary nonstandard/specialized hardware and/or software specifically for electronics

maintenance training will be purchased for our $125,000 investment and how many individuals this will be used to train over what period of time. We have already determined most of the required data from our front-end analysis in Step 2, above. Second, we will need to project exactly how the existing training regimen will change as a result of the new equipment, particularly with respect to duration and instructor needs, as these changes will have a major effect on any savings we might anticipate as a result of the up-front investment. Let us first assume that $12,500,000 would typically be used to train 500 individuals over the next 5 years, at which point the next generation of electronics maintenance training equipment will come on line. The new equipment and software alone, then, will cost approximately $125,000/600 = $208.33 per individual trained. If there were no savings anticipated as a result of this new investment, the average cost to train an individual would rise to $25,000 + $208.33 = $25,208.33. The total cost to train the now 600 students would be $15,124,998.

Let us assume a savings in training time of $1,500 (30 percent × $5,000), a savings in instructor costs of $2,000 (40 percent × $5,000), and a savings in travel and lodging costs of $500. Therefore, costs to train will decrease from the current $25,000 per individual to $21,000 per individual, averaged over the next 5 years. For each year taken individually, the costs are anticipated to be $23,000, $22,000, $21,000, $20,000, and $19,000, decreasing with time, as experience with the new equipment increases. As implied above, this decrease is due roughly to anticipated new costs (averaged over the next 5 years) as follows: $3,500 in student costs; $4,500 in travel, food, and lodging costs; $3,000 in instructor costs; $5,000 in other equipment and facilities costs; and $5,000 in other related costs. The cost for the modified training regimen is therefore $208.33 (new equipment investment) + $21,000 = $21,208.33, a decrease of 15.2 percent in the cost to train an individual. Let us not forget that we are projecting that we will train 120 students each year on the average versus the current 100, an increase of 20 percent in the number of graduates. Over the 5 years we will therefore spend 600 × $21,208.33 = $12,724,998, an increase of only $224,998 (1.8 percent) to train 100 more soldiers. We now move on to the most difficult and critical step in our analysis, a determination of the training effectiveness of each option. See Table IV-1 for a summary of the key elements of this step.

Table IV-1. Summary of Version 1 of the CBI/IVD Case Study

Step 3. Determine the Training Cost of Each Option (TCi)

Assumptions: current training cost as shown.

TC1 = (student costs) + (travel, food, and lodging costs) + (instructor costs) + (equipment and facilities costs) + (other related costs)
= $5,000 + $5,000 + $5,000 + $5,000 + $5,000
= $25,000

TC2 = average cost per student for the new equipment + average of all other costs per student
= total cost for the new equipment/total number of students to be trained over the lifetime of the new equipment + adjusted costs from above
= $125,000/600 + $3,500 + $4,500 + $3,000 + 5,000 + $5,000
= $21,208.33 (a decrease of 15.16%)

Step 4. Determine the Training Effectiveness of Each Option (TEi)

TE1 = (Average Proficiency after the Current Training Regimen)-(Average Proficiency before the Current Training Regimen) = 85 – 25 = 60

TE2 = 89 – 25 = 64 (an increase of 6.66%)

Note that these numbers are on a zero (0) to 100 proficiency/ability scale and may be the result of our best possible estimates and inferences. They take speed and accuracy into account. They are typically not directly measured at this time.

Step 5. Perform a Cost-Effectiveness Analysis

Calculate and compare the two ratios, TE1/TC1 and TE2/TC2.

TE1/TC1 = 60/$25,000 = 2.4/$1,000 = 0.0024/$1 (units of proficiency gained per individual per $1 spent)

TE2/TC2 = 64/$21,208 = 3.018/$1,000 = 0.003018/$1

4. Step 4: Determine the Training Effectiveness of Each Option

The best measures we currently have available from which to estimate the gains in job performance productivity/proficiency are tests given during and at the end of the training sequence and post-training fitness reports that focus on the specific skills for which the individual has been trained. We typically do not have a baseline (pre-training) measure of proficiency since, prior to receiving training on a skill set, individuals are rarely tested, evaluated, or rated on their abilities to perform that skill set. We may find ourselves having to make an assumption about the baseline proficiency for the particular population of individuals trained for the specified MOS through the subject course sequence. Testing a small sample of the subject population for their baseline proficiency in the required set of skills prior to receiving the subject course sequence is a possible solution to this dilemma, but not one that we will propose for this case study.

Let us assume that we have constructed an interval scale that measures proficiency in performing the required electronics maintenance skills, taking both accuracy and speed of performance into account. Our best estimate is that prior to the relevant training sequence an individual would score approximately 25 on this scale, i.e.,

Prior Proficiency = f (Aptitude Test Scores, Fitness Reports) = 25.

This estimate is based on pre-training aptitude testing and fitness reports which were used to select the individuals for training. Measures taken from (1) tests administered during and after training, (2) follow-up testing, and (3) fitness reports, when combined functionally after training under the current regimen, result in a score of 85 on this scale, i.e.,

Posterior Profiency = f (Scores During Training) (Scores After Training) = 85.

Hence, the current training regimen provides on the average a gain of approximately 60 proficiency points, at an expense of $25,000 per individual. That is,

Proficiency Gain = Posterior Proficiency – Prior Proficiency = 85 – 25 = 60.

We must now determine the likely increase, as a result of the modified training regimen, in the average student's proficiency at performing the electronics maintenance tasks that the specified four-course sequence is designed to train. Unfortunately, as discussed above, this increase may only be based on an intelligent guess. But it can be a highly informed guess supported by data from similar existing training applications of

CBI/IVD technology. We can also use past training applications of similar training technologies and the research literature to assist us.

Let us assume that avenues of analysis have led us to certain estimates of the outcomes of the same measures listed above (i.e., test scores during training, test scores post-training, follow-up test scores, fitness reports) and that when functionally combined, we find that the modified training regimen would produce students who scored 89 on our proficiency scale. This is an increase of 4 points over the score of 85 for students receiving the current electronics maintenance training regimen. That is,

Posterior Proficiency = f (same 4 measures) = 89.

Under the new training regimen there will, therefore, be a proficiency gain of 64 points versus the current gain of 60, an increase of slightly more than 6.66 percent in proficiency. That is,

Proficiency Gain = Posterior Proficiency – Prior Proficiency = 89 – 25 = 64.

In support of this hypothetical statistic, we note that Fletcher (1990) has documented an average effect size of approximately .40 standard deviations across 24 studies of IVD applications to military training. This implies an increase for 50th percentile students to about the 65th percentile. If we assume a somewhat arbitrary standard deviation of 10 for the distribution of proficiency gains (not unlike what Fletcher found in his review of the literature), this implies an effect size of $0.4 \times 10 = 4$ and $60 + 4 = 64$. It should be noted that Fletcher's effect size was based on a variety of measures including test scores and performance ratings. We have generalized this increase in effect size to proficiency. See Table IV-1 for a summary of the key elements of this step.

5. Step 5: Perform a Cost-Effectiveness Analysis and Draw Conclusions

We have now reached the final step in our TFDM where we must take the results of the two previous steps and combine them in a manner that will allow us to compare the two resulting proficiency/cost ratios. We accomplish this in three steps.

- The ratio for the current training regimen is 60 proficiency points divided by $25,000 = 2.4/$1,000 = 0.0024/$1 proficiency gain per dollar.
- The ratio for the new training regimen is 64 divided by $21,208 = 3.018/$1,000 = 0.003018/$1 proficiency gain per dollar.

- Therefore, according to this analysis, it is 25.75 percent more cost effective to make the investment in new technology over the subject 5-year period, assuming no new costs would be incurred to stay with the current regimen.

If the current actual equipment trainers were in need of replacement or even upgrade, the cost-effectiveness would be even greater. There are several additional considerations to be factored into our final decision.

Under the new CBI/IVD training regimen, the Army will be able to train a projected 600 men at a cost of $12,724,800 for a gain of 38,400 proficiency units over the next 5 years. To leave training unchanged would cost $12,500,000 to train only 500 men and gain 30,000 proficiency units. Hence, for 1.8 percent more dollars, the Army would get an overall increment of 28 percent in forcewide units of proficiency.

What the Army learns through this early application of a new technology would clear the way in terms of new developments and lessons learned for future similar applications. There is simply some up-front investment to be made in order to derive such benefits. (See Table IV-1 for a summary of the key elements of this final step.) Therefore, from a cost-effectiveness perspective, the investment in the new CBI/IVD equipment and the modification of the current training regimen to suit it is a sound investment. In addition to the increased proficiency, there are other intangible benefits that are sure to accrue.

B. VERSION 2 OF THE CBI/IVD ELECTRONICS MAINTENANCE TRAINING CASE STUDY: PROFICIENCY CONSTANT

This second version of the case study in similar to the first except that we assume that the proficiency gain under the new CBI/IVD training regimen is held constant compared to the old since we are training to a performance level where the same specific set of performance criteria will be met. That is, there will be the same 60-point gain in proficiency. For this to occur, time to train must decrease as will all associated expenses. Assuming that proficiency gain is a negatively accelerating function of time to train, in order to gain only 60 versus 64 proficiency points (6.25 percent less) under the CBI/IVD regimen, we estimate that we must decrease the time to train by an additional multiple of approximately 10 percent on top of the initial reduction of 30 percent. We must therefore reduce anticipated student, instructor, food and lodging, equipment and facilities, and other related costs by 10 percent. The only costs not affected would be travel costs and CBI/IVD equipment costs, which we will assume are $1,708.33 of the estimated $21,208.33.

CBI/IVD costs would be likely to decrease on a per student basis since more students should move through the training pipeline during the lifetime of the equipment under a "training to criterion" regimen and each student would take less time to train. The new cost would therefore be $1,708.33 + ($19,500 × 0.9) = $19,258.33. The new proficiency gain/cost ratio is 60/$19,258.33 = 3.116/$1,000 = 0.003116/$1. This ratio is 29.81 percent greater than that for the old training regimen versus 25.75 percent greater in Version 1. Hence, holding proficiency gain constant is even more cost-effective than allowing it to grow in an unbounded manner.

C. SUMMARY OF THE CASE STUDY

We have seen from the two versions of the case study that it should be possible to perform explicit training cost-effectiveness analyses for training options which take into account appropriate measures and/or estimates of the costs and benefits of training under various regimens. The gathering and/or estimating of cost data is an important and difficult problem, but not nearly as critical a problem as that of estimating the effectiveness, and hence the value, of military training. As a result of this study we have indicated the types of data that are necessary and suggested the requirements for properly combining them.

V. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The purpose of this paper has been to outline a process for utilizing existing data bases and, if necessary, developing new ones to answer key policy questions regarding DoD expenditures of funds for various forms of training. This project has developed a general cost-benefit model called the Training Funds Decision Methodology (TFDM), for conducting analyses in support of questions focused on the desirability of increasing, decreasing, or holding constant various elements of DoD funding for training. Although our methodology is illustrated with a specific case study, it is designed to have general and wide-ranging applicability.

Two versions of the CBI/IVD technology case study are presented, one allowing effectiveness of the resulting modified training regimen to increase beyond its current level and the other holding the effectiveness of the modified training regimen constant. The latter is the one most often encountered in the real world under the concept of training to criterion. In the first case, the emphasis was on unconstrained increased proficiency in performing the tasks for the specified electronics maintenance MOS. In the second case, the emphasis was more on the monetary savings that would result from the modified training regimen for electronics maintenance repair, holding proficiency constant, or as nearly constant, as possible (i.e., training to the same set of performance criteria under the modified training regimen as under the current training regimen).

The TFDM draws on general principles of training cost analysis put forth in detail by previous authors, as well as generalized DoD cost-effectiveness analysis methodologies as developed and applied by other practitioners. The TFDM was designed to make optimal use of existing training cost (as well as effectiveness) data bases. The methodology has emphasized macro-level simplicity and robustness over micro-level detail and complexity. With our methodology as a starting point, it should now be possible to add refinements and augmentations and to address the entire spectrum of potential training cost-effectiveness questions.

A. SUMMARIES OF SPECIFIC CHAPTERS

1. Chapter II, Requirements Analysis

A number of authors have attempted to capture the essential elements of the military training policy-making function as performed by the macro-level training manager. In Chapter II, after providing a succinct statement of the mission and functional responsibilities of the DTP of the OASD for FM&P, we defined the role of the macro-level training manager and addressed the need for macro-level training data bases and tools for their use by the macro-level training manager.

Based on the firmly identified need for macro-level training data bases and techniques and tools for their use, we put forth the objectives of this particular paper, as well as the overall effort for which it provides the final element. We proceeded then to lay the foundation for this effort by clarifying the objectives and products of two previous efforts in this series (Gibson and Orlansky, 1988, and Gibson et al., 1989). First, we presented a model for the conversion of resources to training products which assumes that the training process, as guided by the macro-level training manager, converts money into combat readiness. We went on to present the TMM through which the macro-level training manager performs his management of the conversion process. The essential components of this model were identified as requirements, resources, training activities, performance evaluation quality control, and readiness status. The structural components were the cost-production function, the performance effectiveness function, and the readiness evaluation function.

In Chapter II we also drew upon the work of the Canadian Bureau of Management Consulting (1987) to augment the work of Gibson and Orlansky (1988) and Gibson et al. (1989). Specifically, we looked at the information linkages in cost-effectiveness analysis of training, which essentially provided us with a Canadian version of our TMM with the role of the decision-maker in evaluating alternatives made more explicit and the concept of readiness deleted from the model. We went on to focus on the varying nature of the macro-level training decision contexts and how this affects the level of analyses of both cost and effectiveness elements. Finally, we examined the Canadians' views on providing for efficiency in cost-effectiveness analysis. They take what we in the United States have attempted at TPDC a step further, proposing data bases for cost-effectiveness analysis results themselves (not simply cost and effectiveness independently) and an independent

cost-effectiveness evaluation entity to perform all required military cost-effectiveness analyses as an impartial body.

Finally, in Chapter II, we returned to a consideration of the cost data elements we must draw upon and how they are conditioned, as the Canadians have noted, on the particulars of the requirements and resulting type of training under consideration. A careful consideration of the appropriate cost categories and elements was seen to be critical for the success of the training funds decision process and the supporting training funds decision methodology.

2. Chapter III, The Training Funds Decision Methodology

In Chapter III, we presented our methodology for cost-effectiveness analysis in support of the training policy-making function. First, we reviewed a number of studies of cost-effectiveness analysis of military training options. Next, we identified in some detail the training cost and effectiveness data requirements and data sources for cost-effectiveness analysis of military training options. Finally, drawing upon previous material, we presented our own training funds decision methodology in support of the macro-level decision-maker for training policy.

In Chapter III we reviewed seven previously published studies, all of which focused on the use of methodologies for cost-effectiveness analysis of military training. Several of these studies were themselves lengthy reviews of other published studies of cost-effectiveness analysis. The purpose here was to lay both a theoretical and pragmatic foundation for what was to follow, based upon a record of such analyses. The seven studies reviewed were:

- *Cost and Effectiveness of Computer-based Instruction in Military Training* (Orlansky and String, 1979)
- *Cost-Effectiveness of Maintenance Simulators for Military Training* (Orlansky and String, 1981)
- *Framework for Evaluating the Cost-Effectiveness of Military Equipment and Procedures* (Chatelier et al., 1985)
- "Cost-Effectiveness of Military Training" (Orlansky, 1985)
- "A Model of Cost/Effectiveness Analyses of Training Devices" (von Baeyer, 1985)
- *Economic Issues in Cost-Effectiveness Analyses of Military Skill Training* (Solomon, 1986)

- *Recent Studies on the Cost-Effectiveness of Military Training in TTCP Countries* (Fletcher and Orlansky, 1989)

It was found that the required categories of cost data were well understood and that the specific requirements for the necessary training cost data bases to make these data accessible were rapidly taking shape. Unfortunately, only limited portions of the required data bases have been implemented and plans for moving forward with this critical need were found to be relatively sparse.

Little has been done during the past decade to create the necessary on-line data bases to support cost-effectiveness analyses of training. With respect to the modified training cost data requirements and sources, we found that we faced an even more difficult situation than we did for existing training regimens. The categories of cost data required remained basically unchanged, except for a greater emphasis on up-front research, development, and acquisition costs. Finally, it was found that the data necessary for comparing the effectiveness of different training regimens have been identified by a number of authors. However, few of these data were being systematically maintained in data bases or even appeared to be used systematically in published research studies.

Finally, we provided a general overview of our five-step TFDM procedure. Our goal was that it serve as a general guide for the case study, with which we then proceeded. The case study involved the application of CBI/IVD training techniques and equipment to electronics maintenance training. The purpose of this application is to provide the additional insight needed to augment and refine the general TFDM we had outlined.

The five steps in the general methodology were the following: (1) Frame the question; (2) Make the options explicit; (3) Determine the costs of the options; (4) Determine the training effectiveness of the options; (5) Perform cost-effectiveness calculations and draw conclusions.

3. Chapter IV, Case Study

In Chapter IV we saw from the two versions of the case study that it should be possible to perform explicit training cost-effectiveness analyses for training options which take into account appropriate measures and/or estimates of the costs and benefits of training under various regimens. The gathering and/or estimating of cost data was seen to be an important and difficult problem, but not nearly as critical a problem as that of estimating the effectiveness, and hence the value, of military training. Through the case study we indicated the types of data that are necessary and suggested the requirements for properly

combining them. However, it was necessary to stop short of concluding exactly how to gather and combine the necessary data. In most real-world cases, this process would necessarily be ad hoc and based on a set of guidelines. It would depend on what data were currently available and what new data might be gathered within the time frame of interest.

In both versions of our CBI/IVD electronics maintenance training case study, we saw that the actual gains in training effectiveness for our investment were significant. In the first version of our hypothetical case study, we found a cost decrease of 15.16 percent, a training effectiveness increase of 6.66 percent, and a cost-effectiveness increase of 25.75 percent. In the second version, we found a cost decrease of 22.97 percent, no change in training effectiveness (per our arbitrary assumption of training to criterion), and a 29.83 percent increase in cost effectiveness (a 15.84 percent greater increase in cost-effectiveness than that for Version 1).

In both cases, the recommendation was to move forward with the expenditure, not only because of the anticipated gains in training effectiveness, but also because of the value of new technology insertion and other somewhat intangible and unmeasurable aspects of the new training technology. An important aspect of the new CBI/IVD technology used in these case studies is its closer approximation to the real-world setting in which actual electronics maintenance activities will occur. The reader is cautioned that these findings are only representative of what could be expected from such a calculation. Their purpose is only to demonstrate the operation and utility of the TFDM and should not be used to promote the specific use of CBI/IVD. While our findings are likely to be comparable to real data on CBI/IVD utility, they are based only on estimates derived from the literature and some rather arbitrary cost assumptions made for clarity of presentation.

B. CONCLUSIONS AND RECOMMENDATIONS

The fundamental utility of the TFDM concept lies in its inherent objectivity and reliability. The TFDM will provide the training policy-maker with a systematic, auditable methodology that is comprehensive enough to serve his current functions and flexible enough to accommodate foreseeable changes in the planning, programming, and budgeting cycle. Instead of making purely experience-based decisions concerning the type, amount, medium, and mix of training that is best for the military today, the training policy-maker will have a set of flexible, comprehensive heuristics with which to guide his decision processes. These heuristics will also promote the development of justifications which are directly derived from the cost and effectiveness data accessible from today's existing

training cost and effectiveness data bases. In the event that the required data do not exist, the TFDM would assist in the identification of the characteristics associated with the necessary information. In theory, justifications based on a rigorous logic trail and reliable data would be more defensible than those based on subjective preferences. In accordance with this position we recommend that ASD(FM&P)TP:

- Continue to develop and refine the TFDM, moving toward system design and implementation.
- Begin the development of TFDM data bases using past cost-effectiveness analyses.
- Perform one or more additional detailed case studies to validate TFDM and associated data base design and development concepts.
- Establish an organization within OASD(FM&P)TP to oversee and guide the collection of the data necessary to conduct military training cost-effectiveness analyses.

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APPENDIX A

A COMPREHENSIVE COST ELEMENT STRUCTURE FOR MILITARY TRAINING PROGRAMS, COURSES, AND DEVICES

Table 1. A Comprehensive Cost Element Structure for Military Training Programs, Courses, and Devices

A. RESEARCH AND DEVELOPMENT

1. Design

   a. Pay and Allowances
      (1) Military
      (2) Civilian

   b. Other Government Personnel Costs
      (1) Military
      (2) Civilian

   c. Other

2. Component Development

   a. Pay and Allowances
      (1) Military
      (2) Civilian

   b. Other Government Personnel Costs
      (1) Military
      (2) Civilian

   c. Other

3. Producibility Engineering and Planning

   a. Pay and Allowances
      (1) Military
      (2) Civilian

   b. Other Government Personnel Costs
      (1) Military
      (2) Civilian

   c. Other

(continued)

Table 1. (continued)

4. Tooling

   a. Pay and Allowances
      (1) Military
      (2) Civilian

   b. Other Government Personnel Costs
      (1) Military
      (2) Civilian

   c. Other

5. Prototype Manufacturing

   a. Pay and Allowances
      (1) Military
      (2) Civilian

   b. Other Government Personnel Costs
      (1) Military
      (2) Civilian

   c. Other

6. Data

   a. Managerial Data
      (1) Pay and Allowances
         (a) Military
         (b) Civilian
      (2) Other Government Personnel Costs
         (a) Military
         (b) Civilian
      (3) Other

   b. Technical Data
      (1) Pay and Allowances
         (a) Military
         (b) Civilian
      (2) Other Government Personnel Costs
         (a) Military
         (b) Civilian
      (3) Other

(continued)

Table 1. (continued)

7. P/C/D Test and Evaluation

   a. Pay and Allowances
      (1) Military
      (2) Civilian

   b. Other Government Personnel Costs
      (1) Military
      (2) Civilian

   c. Other

8. System/Project Management

   a. Pay and Allowances
      (1) Military
      (2) Civilian

   b. Other Government Personnel Costs
      (1) Military
      (2) Civilian

   c. Other

9. Facilities

10. Other

B. INITIAL INVESTMENT

1. Production

   a. Nonrecurring
      (1) Production Planning
      (2) Production Tooling and Equipment
      (3) Industrial Facilities
      (4) Other

   b. Recurring
      (1) Manufacturing
      (2) Sustaining Engineering
      (3) Sustaining Tooling
      (4) Quality Assurance
      (5) Other

   c. Initial Spares and Repair Parts

(continued)

Table 1. (continued)

2. Engineering Changes

3. Purchased P/C/D--Peculiar Equipment

4. Common Equipment

5. Data

   a. Managerial Data
      (1) Pay and Allowances
      (2) Other Government Personnel Costs
      (3) Other

   b. Technical Data
      (1) Pay and Allowances
      (2) Other Government Personnel Costs
      (3) Other

   c. Instructional Materials
      (1) Pay and Allowances
      (2) Other Government Personnel Costs
      (3) Other

6. Training P/C/D Test and Evaluation

   a. Pay and Allowances

   b. Other Government Personnel Costs

   c. Other

7. System/Project Management

   a. Pay and Allowances

   b. Other Government Personnel Costs

   c. Other

8. Rents

9. Operational/Site Activation

(continued)

Table 1. (continued)

10. Initial Training

    a. Instructors

    b. Maintenance Personnel

11. Transportation

    a. First-Destination

    b. Second-Destination

12. Other

C. OPERATING AND SUPPORT

1. Direct Costs

   a. Instructional Costs
      (1) Pay and Allowances
         (a) Instructors
            (i) Military
            (ii) Civilian
         (b) Supervisors, Administrators and Support Personnel
            (i) Military
            (ii) Civilian
         (c) Maintenance Personnel
            (i) Military
            (ii) Civilian
      (2) Other Government Personnel Costs
         (a) Military
         (b) Civilian
      (3) Consumption
         (a) POL
         (b) Training Munitions
         (c) Utilities
            (i) Electric Power
            (ii) Other
         (d) Instructional Materials
         (e) Other
      (4) Replenishment Spares
      (5) Modification Materiel
      (6) Depot Maintenance
         (a) Labor and Materials
         (b) Second Destination Transportation
         (c) Other
      (7) Other Purchased Services
      (8) Other

(continued)

Table 1. (continued)

b. Training Activity Costs
   (1) Pay and Allowances
      (a) Military
      (b) Civilian
   (2) Other Government Personnel Costs
      (a) Military
      (b) Civilian
   (3) Other
      (a) Consumables
      (b) Other

c. Airfield and Carrier Operations Costs
   (1) Pay and Allowances
      (a) Military
      (b) Civilian
   (2) Other Government Personnel Costs
      (a) Military
      (b) Civilian
   (3) Other

d. Student Costs
   (1) Pay and Allowances
      (a) Military
      (b) Civilian
   (2) Other Student Costs
      (a) Military
      (b) Civilian
   (3) Other Direct Costs

2. Indirect Costs

a. Base Operations
   (1) Pay and Allowances
      (a) Military
      (b) Civilian
   (2) Other Government Personnel Costs
      (a) Military
      (b) Civilian
   (3) Other

b. Inventory and Supply Management
   (1) Pay and Allowances
      (a) Military
      (b) Civilian
   (2) Other Government Personnel Costs
      (a) Military
      (b) Civilian
   (3) Other

(continued)

Table 1. (continued)

c. Military Family Housing Support
    (1) Pay and Allowances
        (a) Military
        (b) Civilian
    (2) Other Government Personnel Costs
        (a) Military
        (b) Civilian
    (3) Other

d. Command Support Costs
    (1) Pay and Allowances
        (a) Military
        (b) Civilian
    (2) Other Government Personnel Costs
        (a) Military
        (b) Civilian
    (3) Other

e. Other Indirect Costs

APPENDIX B

STEPS TO BE TAKEN AND ASSOCIATED QUESTIONS TO BE ASKED IN MAKING TRAINING-POLICY DECISIONS

APPENDIX B

STEPS TO BE TAKEN AND ASSOCIATED QUESTIONS TO BE ASKED IN MAKING TRAINING-POLICY DECISIONS

This brief document, in outline form, overviews 5 key steps to be taken and associated questions to be asked and answered in the course of making training-policy decisions. Implicit in each step is a set of data requirements which must be fulfilled. The 5 major steps are as follows:

I. Make Policy Decision Explicit

II. Make the Training Options Explicit

III. Identify/Assess the Costs of the Options

IV. Identify/Assess the Benefits (Training Effectivenesses) of the Options

V. Perform a Cost-Effectiveness Analysis of the Options.

The elements of these steps and associated questions are discussed, in turn, below.

I. MAKE THE POLICY DECISION EXPLICIT BY CLEARLY DEFINING THE DECISION CONTEXT--THAT IS, FRAME THE TRAINING-POLICY DECISION

There are at least 11 possible questions to be asked in attempting to clearly define the decision context:

A. Is/Are New or Existing Method(s) of Instruction Involved?

B. Are We Concerned With One Training or Operational Resource or a Mix?

C. Are We Concerned With Individual, Unit, and/or Command Performance?

D. Is Our Focus on Technology, Individual Courses, and/or a Broad Specialization Area of Training (e.g., Maintenance)?

E. Are We Seeking the Best Mix of Training and Operational Resources?

F. Are We Interested in the Ease of Training for a New System?

G. Are We Focusing on the Development, Implementation, and/or Evaluation of a Method?

H. Is Our Focus on Tasks and Associated Performance Objectives (i.e., OTJ Requirements)?

I. Is Our Focus the Evaluation of a Training Organization and Infrastructure Versus Individual Courses?

J. Are We Focused on the Analysis of Training Research Versus Training per se?

K. Do Our Decisions Concern Training-Related System Design Versus Training per se?

NOTE: This set of questions is not meant to be all-inclusive. Lessons learned from previous similar analyses, especially with respect to appropriate options, benefits, and costs to consider, are critical to proper and complete definition of the decision context.

II. MAKE THE TRAINING OPTIONS EXPLICIT

The following potential training options must be identified relative to the current decision:

A. Current Training Regimen

B. All Realistically Appropriate Optional Training Regimens

C. Possible Future Alternative Training Regimens Resulting From Successful Research and Development

To be fully specified, we must have answers to at least the following 7 questions for each option:

1. What training type is involved?
2. What are the performance standards to be achieved?
3. What training time and/or frequency is/are involved?
4. What will the training volume be?
5. What training technique(s) will be involved?
6. What is/are the specific course design(s)?
7. What is the specific location of training?

III. IDENTIFY/ASSESS THE COSTS OF EACH OPTION

A. Precisely Focus the Cost Estimates

1. What MOS(s) are involved?
2. What rank(s) are involved?
3. What skills are involved?
4. What specific course or course sequence is involved?

B. Determine the Average Cost to Provide Each Training Option

1. What is the long run average cost to train an individual (i.e., simple formal training costs taking student attrition into account)?
    a. What are the research and development costs?
    b. What are the initial investment costs?
    c. What are the direct operating costs?
    d. What are the support costs?

2. What costs must minimally be included in the direct operating costs?

   a. What are the student costs (taking time to train and wage rate into account)?

   b. What are the travel, food, and lodging costs?

   c. What are the instructor costs?

   d. What are the equipment costs and facilities costs?

   e. What are the other related costs?

3. What special costs must be accounted for in the case of initial applications of a new technology?

   a. What is the cost of adapting the technology to a new application (beyond R&D)?

   b. Are there are any nonstandard/specialized hardware, software, and/or courseware costs?

4. To what cost savings resulting from reduced time to train and increased information retention must we especially attend?

   a. Are there reduced costs for an individual?

   b. Are there reduced costs for the total training infrastructure due to higher throughput?

IV. IDENTIFY/ASSESS THE BENEFITS (TRAINING EFFECTIVENESS) OF EACH OPTION

A. Identify the Level at Which Training Effectiveness Is To Be Assessed

1. Is our focus the individual attainment of specific performance objectives at the end of the training option?
2. Is our focus individual performance within the context of the unit (transfer of training)?
3. Is our focus the unit's ability to accomplish its mission?
4. Is our focus the command's ability to accomplish its mission?

B. Measure Training Effectiveness (Proficiency/Ability Increments)

1. What are the values of certain organizational measures--training time, attrition rates, and recycle rates?

2. What are the values of certain personnel measures--test scores (pre- and post-), work sample evaluations (pre- and post-), measures of satisfaction, and fitness reports (pre- and post-)?

3. What are the values of certain instructional parameters--range of knowledge and performance skills taught and then measured by the assessment procedure?

C. Make Use of Data Bases and the Research Literature as Necessary and Appropriate

1. Are there any relevant previous applications of the same technology?
2. Are there any relevant previous applications of similar technologies?
3. Are data available on key issues such as time to train to criterion, resilience of learned skills to decay over time, value of training beyond criterion level?

D. Do Not Neglect Certain Difficult-to-Measure Benefits That Might Result From an Option

1. Is there greater realism in training?
2. Is the instruction more precisely tailored?
3. Is there qualitatively different training integral to new technoogy, e.g., performance of actions that would ordinarily be harmful to trainees and/or their equipment?

V. PERFORM A COST-EFFECTIVENESS ANALYSIS OF THE OPTIONS

A. Compute the Simple Formal Training Costs for Each Option (see III, above)

Key questions to be asked concerning cost elements are the following:

1. What is the cost impact of any decrease in student training time from the new technology (from the research literature)?
2. What is the cost impact of any decrease in instructor time resulting from the new technology (estimated using the research literature)?

B. Convert the Estimates of Training Effectiveness of Each Option to Common Interval Scale Measures of Student Average Proficiency/ Ability at Performing the Requisite Tasks/Duties/Skills (see IV, above)

1. What are the values of certain measures of student average proficiency/ability gains at performing the requisite tasks/duties/skills for each option, taking speed and accuracy into account?

   a. What are the data on average training effect size due to the alternative training regimens (from the research literature if necessary) for the appropriate student population and performance area?

      (i) Do we have knowledge and performance training outcomes (the results from paper tests and performance tests)?

      (ii) Do we have data on post-training retention of trained skills and learned knowledge?

      (iii) Do we have post-training fitness reports (or estimates of OTJ performance) for students subjected to each training option?

      (iv) Do we have measures of time on task during training (secondary measure)?

      (v) Do we have measures of time to complete instruction (secondary measure)?

      (vi) Do we have measures of time to complete performance/knowledge tests (secondary measure)?

2. What is an appropriate function for converting the various measures of student proficiency/ability gains to an interval scale (if there is not one already)?

3. What is an appropriate function for converting training effect sizes to interval scale estimates of military value of training (readiness?)? [Optional]

C. Calculate Ratios of Effectiveness Divided by Cost

D. Perform Comparisons of Effectiveness/Cost Ratios and Other Key Factors

1. What are the percent difference(s) in cost-effectiveness between/among options?

2. How do the number of trainees through the pipeline per unit time compare?

3. How do the forcewide increases in proficiency compare?

4. How do the total costs of training for all trainees compare?

APPENDIX C

INFORMATION ITEMS FOR TRAINING-POLICY DECISIONS

APPENDIX C
INFORMATION ITEMS FOR TRAINING POLICY DECISIONS

FIVE KEY GROUPINGS FOR INFORMATION ITEMS

I. The Explicit Policy Decision to be Addressed

II. The Explicit Training Options Involved

III. The Costs of the Options

IV. The Benefits (Training Effectivenesses) of the Options

V. Cost-Effectiveness Measures for the Options

I. DECISION CONTEXT INFORMATION ITEMS

1. New method(s) of instruction involved
2. Existing method(s) of instruction involved
3. Training or operational resource(s) involved
4. Specific individual, unit, or command performance knowledge/skills to be measured
5. Technology addressed
6. Individual course(s) involved
7. Broad specialization area of training (e.g., maintenance) involved
8. New system for which training is to be provided
9. Training method to be developed, implemented, or evaluated
10. Tasks and associated performance objectives (i.e., OTJ requirements) to be addressed
11. Training organization and infrastructure to be evaluated
12. Training research to be analyzed
13. Training-related system design decisions to be made

II. INFORMATION ITEMS FOR THE TRAINING OPTIONS

1. Current training regimen
2. Realistically appropriate optional training regimens
3. Possible future alternative training regimens given successful research and development
4. Training type
5. Performance standards to be achieved
6. Training time and/or frequency
7. Training volume
8. Training technique(s) involved
9. Specific course design(s)
10. Location of training

III. INFORMATION ITEMS ADDRESSING THE COST OF EACH OPTION

1. MOS(s) involved
2. Rank(s) involved
3. Skills involved
4. Specific course or course sequence involved
5. The long run average cost to train an individual (i.e., simple formal training costs taking student attrition into account)
6. Research and development costs
7. Initial investment costs
8. Direct operating costs
9. Support costs
10. Student costs (time to train and wage rate)
11. Travel, food, and lodging costs
12. Instructor costs
13. Equipment costs and facilities costs
14. Other related costs
15. Cost of adapting technology to a new application (beyond R&D)

16. Nonstandard/specialized hardware, software, and courseware costs

17. Cost savings resulting from reduced time to train and increased information retention including reduced costs for an individual and reduced costs for total training infrastructure due to higher throughput

IV. INFORMATION ITEMS ADDRESSING THE BENEFITS (TRAINING EFFECTIVENESS) OF EACH OPTION

1. The level at which training effectiveness is to be assessed
2. Specific performance objectives to be met by the individual trainee at the end of the training option
3. Individual performance objectives within the context of the unit (transfer of training)
4. Performance objectives with respect to unit ability to accomplish its mission
5. Performance objectives with respect to command ability to accomplish its mission
6. Training effectiveness (proficiency/ability increments) measures
7. Organizational measures--training time, attrition rates, recycle rates
8. Personnel measures--test scores (pre- and post-), work sample evaluations (pre- and post-), measures of satisfaction, fitness reports (pre- and post-)
9. Instructional parameters--range of knowledge and performance skills taught and then measured by the assessment procedure
10. Relevant data bases and research literature
11. Previous applications of the same technology
12. Previous applications of similar technologies
13. Time to train to criterion
14. Resilience of learned skills to decay over time
15. Value of training beyond criterion level
16. Certain difficult-to-measure benefits that might result from greater realism in training, more precisely tailored instruction, and qualitatively different training integral to a new technology (e.g., performance of actions that would ordinarily be harmful to trainees or their equipment)

V. INFORMATION ITEMS ADDRESSING THE PERFORMANCE OF A COST-EFFECTIVENESS ANALYSIS OF THE OPTIONS

1. The simple formal training costs for each option (see III, above)
2. Cost impact of decrease in student training time to train resulting from the new technology (from the research literature)
3. Cost impact of decrease in instructor time resulting from the new technology (estimated from the research literature)
4. Measures of student average proficiency/ability gains in performing the requisite tasks/duties/skills for each option, taking speed and accuracy into account (see IV, above)
5. Data on average training effect size due to the alternative training regimen (from the research literature) for the appropriate student population and performance area
6. Function for converting measures of student proficiency/ability gains to an interval scale (if not already on one)
7. Function for converting training effect sizes to interval scale estimates of military value of training (readiness?) [Optional]
8. Post-training fitness reports (or estimates) for students subjected to each training option
9. Knowledge and performance training outcomes (paper tests and performance tests)
10. Retention of trained skills and learned knowledge
11. Time on task during training (secondary measure)
12. Time to complete instruction (secondary measure)
13. Time to complete performance/knowledge tests (secondary measure)
14. Ratios of effectiveness divided by cost
15. Comparisons of effectiveness/cost ratios
16. Number of trainees through the pipeline per unit time for each option
17. Forcewide increase in proficiency for each option
18. Total cost of training all trainees for each option